1 ELECTRICAL SERVICES MATERIALS & WORKMANSHIP

1.1 Materials and Workmanship Generally

1.1.1 Unless stated otherwise, all equipment, materials and areas of workmanship covered by BS or CP or other approved standards, whether detailed in this Specification or not, shall comply with their requirements.

1.1.2 All materials and equipment utilised shall be installed in strict accordance with the manufacturer's recommendations. Where owing to site conditions materials cannot be installed in accordance with the manufacturer's recommendations, the Contractor shall notify the Contract Administrator prior to commencement of installation.

1.1.3 All workmanship shall be subject to the approval of the Contract Administrator.

1.1.4 The Contract Administrator reserves the right to reject any part of the installation not complying with this Specification and/or the Contract Drawings, and the Contractor shall carry out the necessary remedial work or replacement free of charge and without delay to the Contract.

1.1.5 No approval or any acceptance by the Contract Administrator shall relieve the Contractor of the responsibilities under the Contract for the quality of materials and the standard of workmanship of the works.

1.1.6 Where material manufacturers and/or catalogue numbers are specified they shall be strictly adhered to. In the event of discontinuation of such materials or companies the Contractor shall notify the Contract Administrator who will specify an alternative.

1.2 Sizes of Plant and Equipment

1.2.1 The duties and ratings of switchgear, etc. described in this Specification and on the Contract Drawings are the minimum necessary for the operation of the complete systems. The Contractor shall be responsible for checking the duties against the working drawings and for making all necessary adjustments to achieve the design performance.

1.2.2 The Contractor shall be responsible for obtaining plant and equipment selections from the selected manufacturers which fall within the middle of the range of the plants performance and not at the maximum or minimum capabilities.

1.2.3 The Contractor shall submit details of the plant selections to the Contract Administrator for approval prior to manufacture (or delivery, for "off the shelf" items).

1.3 Suitability for Site Conditions

1.3.1 All materials and equipment installed shall be suitable in all respects for the site conditions, in terms of both climate and conditions in which the items are to be installed and also in terms of the specific location on site.

1.4 Protection, Painting and Galvanising

1.4.1 Unless noted otherwise elsewhere in this Specification, all cut ends of galvanised steelwork (conduit, tray support systems etc.) shall be treated as detailed within this clause. Scratches and other damage to galvanised finishes shall also be repaired as described below, provided that such repairs have been previously agreed with the Contract Administrator.

1.4.2 All exposed, unfinished steelwork (such as running threads on conduit systems) shall also be treated as described below. In all cases, cut ends shall be files and /or reamed to remove burrs, swarfe and sharp edges, to give a smooth finish. Any rust or other surface scaling shall be completely removed and where necessary a degreasing solution shall be applied.

1.4.3 A cold galvanising treatment shall be applied over the entire area of exposed metal, overlapping the surrounding sound galvanised finish by not less than 25mm.

1.5 Installation of Apparatus and Fixings

1.5.1 Wherever possible, equipment shall be fixed using fire rated fixings such as concrete screws or roundhead sherardised woodscrews and metal wall plugs. Such screws shall be of the largest size admitted by the fixing holes of the equipment and shall be of sufficient length to secure the item to the approval of the Contract Administrator.

1.5.2 Unless otherwise indicated elsewhere in the Specification no item shall be fixed with less than 2 No screws.

1.5.3 Where necessary due to the nature of the building fabric, spring toggles or expanding anchors may be used, with sizes and dispositions generally as described above.

1.5.4 In concrete and similar materials, rawlbolts and similar devices shall be used for fixings in excess of 6mm diameter. They shall be sherardised and shall incorporate a washer and hexagon head drive.

1.5.5 Shot fire and chemical or thermal welding systems shall only be used with the expressed permission of the Contract Administrator.

1.5.6 Where suitable structural steelwork exists, it shall be generally acceptable to employ knock-on type clips, but the Contractor shall gain approval for their use from the Contract Administrator prior to commencement.

1.5.7 Under no circumstances shall any structural steelwork be fixed to or modified in any way without the prior approval of the Contract Administrator.

1.5.8 All support bracketry shall be constructed from a preparatory system of pre-galvanised mild steel 40x40mm channel to BS EN 10162 and BS 2898/BS EN 755. Accessories shall be of 6mm (minimum) hot-dip galvanised BS EN ISO 1461 mild steel and all supports shall provide a load factor of 1.6 in accordance with BS 5950: Part 5.

1.5.9 All cut ends shall be treated with a cold galvanising agent as described elsewhere in this Specification. They shall be cut square and shall be fitted with blue uPVC end caps.

1.5.10 Where required, equipment shall be installed and fitted to ensure the fire integrity of both apartments and communal areas. This is to include the installation of putty pads within socket boxes, or other equal and approved measures, the installation of fire barriers within trunking and the fire-sealing of cable penetrations.

1.6 Current Rating

1.6.1 Continuous and short circuit ratings of equipment are indicated in the Specification/Contract Drawings or are available on request.

1.6.2 Where such specification is omitted, the Contractor shall ensure that every current carrying part of the equipment, including contactors, switches, isolators, tapping switches, fuses, busbars, current transformers, connections and joints, shall be capable of carrying their site rated current continuously under the site conditions, as specified, and in no case shall the permitted temperature rise be exceeded.

1.7 Mounting Heights

1.7.1 Unless otherwise stated on the Contract Drawings or elsewhere in this Specification, the following mounting heights from the horizontal centre line of the item concerned to the finished floor level shall be adopted:

- Wall Sensors 1500mm
- Lighting Switches 1200mm
- Wall Mounted Luminaires and Indicating/Warning Lights 2000mm
- Socket Outlets 500mm
- Fused Spurs 500mm
- Telephone Outlets 500mm
- Fire Alarm Breakglasses 1200mm
- Fire Alarm Bells/Sounders 2300mm
- Equipment Isolating Switches 1500mm
- Control/Indicating Panels 1800mm

1.7.2 The above mounting heights are for design purposes only. Prior to installation all mounting heights shall be verified by the Contractor via written confirmation from the Contract Administrator.

1.7.3 Power and ancillary services outlets and items of equipment detailed on the Contract Drawings may have their mounting height specified by a letter reference shown adjacent to the particular outlet or item of equipment. Where letters are detailed mounting heights will be identified on the Contract Drawings

1.8 Enclosures

1.8.1 Unless noted otherwise elsewhere in this Specification or on the Contract Drawings, enclosures shall be rated as follows:

Location	Ingress Protection to IEC144
Dry indoor locations	IP41
Plantrooms, risers, etc.	IP44
Damp indoor locations and externally	IP65

1.8.2 Enclosures shall be either of coated metallic, or of polycarbonate construction as specified. They shall meet the impact resistance requirements of BS EN 50 102: 1995, IK10 or IK07 respectively.

1.8.3 Where gaskets are provided they shall be non-deteriorating and permanently fixed. Hinged doors, locks, vision panels etc., shall be provided as specified.

1.9 Labelling and Circuit Charts

1.9.1 Means of identification such as notices, diagrams and charts shall be in accordance with the IEE Regulations.

1.9.2 Each switchboard and all units mounted thereon, and each distribution board shall be identified by an externally-fitted label inscribed with the circuit reference shown in the Schedules and Record Drawings.

1.9.3 Each fused switch, isolator, indicating switch, starter and control switch controlling remote equipment shall be identified by an externally fitted approved label or engraving indicating the equipment controlled.

1.9.4 Each junction box shall be identified by an externally fitted approved label indicating the type of service contained, such as security, telecommunication and fire alarm, etc.

1.9.5 All labels shall incorporate the year of installation of the associated equipment in the bottom right hand corner.

1.9.6 General labels shall be of non-glossy and of non-corrodible materials, having black letters not less than 6 mm high engraved on a white background, and shall be fixed by two or four round head chromium plated screws of suitable size secured by tapped holes or washers and nuts. Where fitted to IP55 (or higher standard) equipment, labels shall be affixed using an epoxy-based two-part resin adhesive.

1.9.7 Labels for essential services shall be similar specification but red characters on a white background. Each conduit draw-box containing generator fed essential services shall be painted orange and fitted with engraved label reading "Generator Essential Services".

1.9.8 A paper print of the record drawing of the appropriate Mains Distribution diagram shall be mounted in a glazed frame in each Main Switch Room, Sub-Switch Room, Sub-Station and Generator Room as applicable.

1.9.9 Similar diagrams of connections shall be provided for emergency lighting, fire alarm systems, etc.

1.9.10 Typewritten circuit lists mounted in transparent plastic envelopes shall be fixed to the inside face of all distribution board doors or covers, or mounted in glazed frames adjacent to the distribution boards.

1.9.11 The list shall indicate what each circuit controls, the circuit number, cable size and type, the CPC size and type, and the rating and type of the protective device used. It shall also define circuit volt drop, earth loop impedance, prospective short circuit fault current and sub-main voltage drop at the distribution board, and the year of installation.

1.9.12 Each switchboard, generator control panel and distribution board shall be fitted with a label stating details of the Consultant Services Engineer.

1.9.13 The details of all labelling legends shall be submitted to the Contract Administrator for approval prior to commencement of engraving.

1.10 Permit to Work

1.10.1 The Contractor shall employ a competent Authorised Person to control electrical services, 24 hours of the day, 7 days a week from the date of appointment until handover to the Client on completion of the works.

1.10.2 The Contractor shall arrange for controlled isolation of all electrical supplies.

1.10.3 The system instituted shall ensure safe energisation of services throughout the project. Each switching operation shall be logged against the Authorised Persons' signature, and shall be accompanied by a test result sheet for the service concerned.

1.10.4 Switching of electrical systems shall be under the strict control of a permit to work regime instigated by the Contractors authorised person, and the switching log shall be available on site for inspection at all times.

1.11 Setting Out of Works

1.11.1 The exact dimensioned positions of all items of plant and equipment shall be as detailed in the Contractors approved installation drawings.

1.11.2 Where items are mounted horizontally adjacent on a wall, they shall be aligned through the top edges, with equal spacing between.

1.11.3 Where vertically mounted, they shall be aligned with one of the side faces, as directed by the Contract Administrator.

1.11.4 In all cases, the positions of equipment shall be determined such that a neat and symmetrical installation is achieved, taking full account of the operational maintenance requirements of each individual item.

1.11.5 In all cases, the final configuration of adjacent items will be determined by the Contract Administrator.

1.12 Cable Types

1.12.1 All cable types shall be as indicated on the Contract Drawings, Schedules and/or herein, as shall fully comply with the detailed requirements of the following Sub-Clauses.

1.12.2 All cables shall be provided by a BASEC approved manufacturer, but only one manufacturer allowed for each type of cable. See the Manufacturers/Suppliers List bound within this Specification.

1.13 Single Core Cable Type 6491B

1.13.1 All 6491B cable shall comply fully with the requirements of BS 6004, 6360, 7211 and BS EN 50265-1. It shall have solid or stranded copper conductors to BS 6360 and an overall low smoke zero halogen insulation to BS 7211. It shall be 450/750v grade.

1.13.2 Insulation colours shall comply with table 51A of the BS7671 Regulations. Brown, Black and Grey shall be used for all three-phase circuits. Where used for up to 24v AC systems, insulation shall be coloured violet.

1.13.3 No live conductor shall be smaller than 1.5mm², and all conductors shall be sized as detailed elsewhere.

1.13.4 The cable shall be suitable for minimum bending radii as follows:

- Diameter up to 10mm - 3 x overall diameter
- Diameter 10mm to 25mm - 4 x overall diameter
- Diameter 25mm or greater - 6 x overall diameter

1.14 EPR/HOFR Flexible Cable Type 318*TQ

1.14.1 All ERP insulated HOFR sheathed Flexible Cable Type 318*TQ (where * denotes number of cores) shall comply fully with the requirements of BS 6500. It shall have multi-strand flexible tinned copper conductors to BS 6360, Ethylene Propylene Rubber (EPR) insulation to each core (type GP.1) to CENELEC HD 22.1 S2 and Heat and Oil resistant, Flame Retardant (HOFR) overall sheath to CENELEC HD 22.1 S2. It shall be 300/500v grade.

1.14.2 It shall be suitable for use in a maximum ambient temperatures of 85°C.

1.14.3 Insulation colours shall comply with Table 51B of the IEE Regulations for up to five cores. Above this number all core insulation shall be white, with black numerals. No conductor size smaller than 1mm² shall be used, and all conductors shall be sized as detailed elsewhere.

1.14.4 The cable shall be suitable for a minimum bending radius of 6 x overall diameter up to 25mm, and 8 x overall diameter for cables exceeding 25mm.

1.15 PVC/LSF Flexible Cable Type 318-LSF

1.15.1 All PVC/LSF Flexible Cable Type 318-LSF shall comply fully with 3BS 6500, Table 16 (where applicable), but with a sheath compound designed for reduced smoke propagation and no halogen emissions under fire conditions. It shall have multi-strand annealed copper conductors, polyvinylchloride (PVC) insulation to each core to BS 6746, and low smoke and fume overall sheath, to BS EN 50265-1. It shall be 300/500v grade.

1.15.2 It shall be suitable for use in ambient temperatures of between 0°C and +70°C. Insulation colours shall comply with Table 51B of the IEE Regulations for up to five cores. Above this number, cores shall be coloured to an approved scheme to the approval of the Contractor.

1.15.3 No conductor size smaller than 1mm² shall be used, and all conductors shall be sized as detailed elsewhere.

1.15.4 The cable shall be suitable for a minimum bending radius of 6 x overall diameter.

1.16 XLPE/PVC Single Core Cable Type 6181XY

1.16.1 All XLPE/PVC Single Core Cable Type 6181 XY shall comply fully with BS 5467. It shall have a stranded annealed copper conductor to BS 6360, cross-linked Polyethylene (XLPE) insulation (type GP8) to CENELEC HD 22.1 S2, and polyvinylchloride (PVC) overall sheath to BS 6746. It shall be 600/1000v grade.

1.16.2 It shall be suitable for a maximum operating temperature of 90°C. Insulation/sheath colours shall be either red/red or black/black.

1.16.3 The cable shall be suitable for the following bending radii:

- Diameter up to 10mm - 3 x overall diameter
- Diameter 10mm to 25mm - 4 x overall diameter
- Diameter 25mm or greater - 6 x overall diameter

1.17 XLPE/LSF/SWA/LSF Cables

1.17.1 All XLPE/LSF/SWA/LSF Cable shall comply fully with BS 6724. It shall have stranded annealed copper conductors (circular up to 35mm², shaped for 50mm² and greater), cross-linked polyethylene (XLPE) insulation to each core to CENELEC HD 22.1 S2, low smoke and fume (LSF) extruded bedding to BS 6724, steel wire armouring (SWA) to BS EN 10257-1 and black low smoke and fume (LSF) overall sheath. It shall be 600/1000v grade.

1.17.2 LSF insulation material shall comply with the following criteria and BS 7211.

- Oxygen index 30%
- Hydrogen chloride emission not greater than 0.5% max @ 800^{O}C

1.17.3 The cable shall comply with the requirements for fire testing under BS EN 50265-1 3, shall be classified as low smoke under the 3 metre cube test as specified in BS 7622, and shall comply with BS 7629.

1.17.4 It shall be suitable for a maximum operating temperature of 90°C.

1.17.5 Insulation colours for 2 to 4 cores shall comply with Table 51A of the IEE Regulations. For larger numbers of cores, insulation shall be white with black numerals.

1.17.6 No conductor size smaller than 1.5mm² shall be used, and all conductors shall be sized for the following minimum bending radii:

- Up to 16mm² - 6 x overall diameter
- 25mm² and greater - 8 x overall diameter

1.18 Mineral Insulated Cables with Insulating Oversheath

1.18.1 All Mineral Insulated Cable with Insulating Oversheath shall comply fully with BS 6207, and BS 6387 categories C, W and Z, simultaneously. It shall have copper conductors to BS 6360 compressed magnesium oxide powder insulation, a phosphorus de-oxidised copper sheath to BS EN 1976/BS EN 1978, and an overall sheath of either polyvinylchloride (PVC) or low smoke and fume (LSF) material, as specified. It shall be 500v rated for light grade, and 750v rated for heavy grade as detailed elsewhere.

1.18.2 Where LSF sheathing is specified, it shall comply with the following criteria and BS 7211.

- Oxygen index 30%
- Hydrogen chloride emissions not greater than 0.5% max @ 800^{O}C

1.18.3 The cable shall comply with the requirements of fire testing under BS EN 50265-1, shall be classified as low smoke under the 3 metre cube test as specified in BS 7622, and shall comply with BS 7629.

1.18.4 The cable shall be certified to VDE 0284 and IEC 331 for fire resistance.

1.18.5 It shall be suitable for continuous operating temperatures of 80°C for LSF and 70°C for

1.18.6 PVC.

1.18.7 No conductor size smaller than 1.5mm²shall be used, and all conductors shall be sized as detailed elsewhere.

1.18.8 The cable shall be suitable for a minimum bending radius of 6 x overall diameter.

1.19 Glands for Flexible Cables – Unbraided

1.19.1 Flexible cables without internal braiding shall terminate into equipment using brass compression glands to BS EN 50262 type A1 for standard installations, and type A2 for external or plantroom use. They shall have internal sealing gaskets of a resilient, flexible material, correctly sized to achieve a firm grip on the cable without excessive tightening of the gland. They shall be installed in compliance with BS 6121: Part 5.

1.19.2 Only one cable shall pass through any individual gland.

1.19.3 Glands shall be fitted directly into BS 3643: Parts 1 and 2 threaded entries, or shall be provided with metallic adapters where equipment has a non-standard threaded entry.

1.19.4 Type A2 weatherproof glands shall be fitted with tight-fitting shrouds of polyvinylchloride (PVC) or low smoke and fume (LSF) material, to match associated cable sheathing. They shall be of a type and size to ensure IP 66 ingress protection to BS EN 60529.

1.19.5 Where no threaded entries exist, glands shall be secured using brass locknuts, or knurled-edge locking rings where space constraints dictate their use.

1.20 Glands for SWA Cables - Type BW

1.20.1 Steel wire armoured (SWA) cables in standard indoor situations shall terminate into equipment using brass cable glands to BS EN 50262, type BW.

1.20.2 They shall be of two-part construction with an inner flexible seal, and shall clamp the cable armouring to both secure the cable in place and provide an effective, continuous earth path. They shall be installed in compliance with BS 6121: Part 5.

1.20.3 Glands shall be fitted directly into BS 3643: Parts 1 and 2 threaded entries, or shall be provided with metallic adapters with integral earth continuity conductors where equipment has a non-standard threaded entry. Such conductors shall be of copper construction with green and yellow oversheath, sized in compliance with 543-01-04 of the IEE Regulations.

1.20.4 Where made off into equipment without threaded entries, all glands shall incorporate a brass earthtag and locknut. Earthtags shall be fitted in the outside of the enclosure, with a solid brass hexagon head setscrew and fullnut, of the maximum size admitted by the earthtag hole, bolted through from the outside. A green and yellow 6491X protective conductor, sized in compliance with IEE Regulation 543-01-04, shall extend from a ring- type compression lug at this bolted connection to the equipment earthing terminal.

1.20.5 All glands shall be fitted with black polyvinylchloride (PVC) or low smoke and fume (LSF) shrouds, to match the cable sheath material and colour.

1.21 Glands for SWA Cables - Type CW

1.21.1 Steel wire armoured (SWA) cables in external and plantroom locations shall terminate into equipment using brass cable glands to BS EN 50262, type CW. They shall be of three-part construction with an inner flexible seal, and shall clamp the cable armouring to both secure the cable in place and provide an effective, continuous earth path. They shall be installed in compliance with BS 6121: Part 5.

1.21.2 Glands shall be fitted directly into BS 3643: Parts 1 and 2 threaded entries, or shall be provided with metallic adapters with integral earth continuity conductors where equipment has a non-standard thread entry. Such conductors shall be of copper construction with green and yellow oversheath, sized in compliance with 543-01-04 of the IEE Regulations.

1.21.3 Where made off into equipment without threaded entries, all glands shall incorporate a brass earthtag and locknut. Earthtags shall be fitted to the inside of the enclosure, bent up to an angle of 90°. A hexagon head setscrew and fullnut of the maximum size admitted by the earthtag shall be provided, with 6491X protective conductor from this bolted connection to the equipment earth terminal. The conductor shall be sized in compliance with IEE Regulation 543-01-04, and shall be connected to the earthtag bolt using a ring-type compression lug.

1.21.4 All glands shall be fitted with black polyvinylchloride (PVC) or low smoke and fume (LSF) shrouds, to match the cable sheath material and colour.

1.22 Fire Resistant Cables

1.22.1 Fire resistant cable shall be BASEC and LPCB approved and shall comply fully with BS

1.22.2 7629: Part 1, Clause 26.2 for enhanced fire resistant cables. It shall have plain annealed copper solid conductors complying with BS 6360 Class 1, cross-linked medium impact damage and moisture resistant insulation (type E15) to each core, a laminated copper tape screen bonded to sheath and to integral circuit protective conductor, low smoke and zero halogen (LSOH) thermoplastic overall sheath, of red colour when used for all fire detection and alarm installations, and shall be 300/500Volts grade.

1.22.3 Fire resistant cable shall comply with the requirements for fire testing under BS EN 50265-2-1 and -4, shall be classified as halogen free under BS EN 50267-2-1, shall be classified as having low smoke emissions under BS EN 50268-2, and shall be fire resistant to Categories A, B, C, S, W, X and Z under BS 6387, EN 50200PH120 and BS

1.22.4 8434-2:120 minutes.

1.22.5 Fire resistant cable shall be suitable for a conductor operating temperature range of - 20°C to +70°C.

1.22.6 Fire resistant cable shall follow harmonised insulation colours, as follows:

- for 2 cores – brown-blue
- for 3 cores – brown-black-blue
- for 4 cores – brown-black-grey-blue
- with green/yellow for any earth conductor
- For more cores marker cores shall be provided in each layer with remaining cores in white and with all cores numbered with black numerals.

1.22.7 A conductor size smaller than 1.5mm² shall not be used.

1.22.8 In order to maintain fire performance, all fire resistant cables shall be installed in accordance with the manufacturer's recommendations, using purpose-made stainless steel red LSOH fixing clips and LSOH glands designed exclusively for the cable used. Fixings shall be neatly applied and spaced not more than 300mm apart on horizontal runs and not more than 400mm apart on vertical runs, throughout their length and whether or not installed in void spaces and all cable routes shall be planned for a minimum bending radius of eight times the overall diameter of the cable.

1.23 Cable Installation Methods

1.23.1 General

1.23.2 All cables shall be installed in strict accordance with the following detailed methods, unless specifically instructed otherwise elsewhere in this Specification or in the Contract Drawings.

1.23.3 All cables shall be purchased directly from one manufacturer for each type of cable approved by the Contractor, unless specific approval is given to their purchase, in exceptional circumstances, from a non-manufacturing stockist. In such a case, manufacturers' test certificates relating to the particular lengths of cable in question shall be made available for inspection by the Contract Administrator prior to delivery to site.

1.23.4 All cables shall be new and unused and shall be delivered to site with the manufacturer's seals, labels, or other proof of origin intact. Such labels and seals shall not be removed until the cable is required for use, and shall be retained for inspection by the Contract Administrator.

1.23.5 Reduced size neutral conductors shall not be provided. Neutral conductors shall be as a minimum of equivalent cross sectional area to phase conductor, or larger subject to detail design.

1.23.6 The Contractor shall be responsible for making accurate measurements for preparation of his Tender including whatever allowances are necessary to cover cutting, jointing and terminating, snaking in trenches and wastage. Where design lengths are given, the Contractor shall compare these lengths with those measured on site.

1.23.7 Any lengths found to vary by more than 10% shall be notified to the Contract Administrator, in order that the cable size may be checked. In such cases a minimum of fourteen days' notice shall be given in writing to allow for the execution of this process, and the Contractor shall be responsible for ensuring that this does not impinge upon the Construction Programme.

1.23.8 Under no circumstances shall design lengths be used for tender or purchasing purposes. It shall be the sole responsibility of the Contractor to make his own assessment of lengths at tender stage, and all cable routes shall be measured on site prior to ordering.

1.23.9 The Contract Drawings shall indicate generally the routes and the manner in which cables shall be installed.

1.23.10 The Contractor shall develop the information to installation standard and incorporate it on the Installation Drawings. This shall include details relating to the arrangement of cables and methods of installation, which are required to be produced under the Contract, for approval in detail by the Contract Administrator before any work is commenced.

1.23.11 All cable routes shall also be marked out on the site, and the approval of the Contract Administrator obtained, before commencement of trench excavation or the fixing of cable primary/secondary supports and/or containment systems to ensure any deviations due to site conditions are approved prior to commencement of works.

1.23.12 No cables shall be installed or removed from the drum unless the ambient temperature and the temperature of the cable are above 0°C and have been so for the previous 24 hours.

1.23.13 For the purposes of this Specification, cable runs which are inclined to the horizontal at an angle not exceeding 60 degrees shall be considered horizontal. Runs inclined at 60 degrees or more shall be considered as vertical.

1.23.14 Full details, with illustrations, of all cable supports and fixing devices shall be submitted to the Contract Administrator for approval before any orders are placed or work put in hand. All cable supports and fixing devices shall be designed to have a factor of safety of not less than 4.

1.23.15 Holes required for 'Rawlbolts', 'Redhead' bolts, toggle bolts and plugged screw fixings to masonry and/or partitions shall be drilled by the Contractor.

1.23.16 Throughout the installation, and particularly in damp locations, adequate precautions shall be taken to eliminate risk of electrolytic corrosion between dissimilar metals.

1.23.17 Where cables are run externally and exposed to direct sunlight due allowance shall be made for the effect of solar heating when assessing their current rating.

1.23.18 All cables shall run directly from point to point without joints unless the length required is in excess of the length obtainable in one piece from the cable manufacturer. In such a case, the position of each and every joint shall be approved by the Contract Administrator.

1.23.19 No other joints, whether straight through or tee, shall be permitted unless they are specifically called for on the Contract Drawings or elsewhere in this Specification.

1.24 Cable Handling

1.24.1 Sufficient and adequate plant and equipment necessary for the unloading, handling, transportation and installation of the cables shall be provided by the Contractor at his own expense and shall not be removed from the site without the authorisation of the Contract Administrator.

1.24.2 All armoured cables shall be delivered to site in strong returnable wooden drums lagged with closely fitting battens.

1.24.3 Cable drums shall be made of timber, pressure-impregnated against fungal and insect attacks, and each drum shall bear a unique distinguishing number neatly chiselled or branded with a hot iron on the outside of one flange.

1.24.4 Each cable drum shall have stencilled on the outside of one flange full details of the cable length, conductor size, number of cores, cable type, voltage grade, gross and nett weights, and the cable reference number in accordance with the Drawings or Cable Schedules. The direction of rolling shall be marked by an arrow.

1.24.5 The inner end of the cable shall be properly secured and shall be adequately protected against mechanical damage where it emerges from the side of the drum. The outer end of the cable shall also be securely anchored.

1.24.6 All cable drums shall be handled with care to ensure that they are not damaged, and all handling shall be carried out using adequate plant and equipment.

1.24.7 All empty cable drums shall be stacked neatly in such a manner as not to obstruct access to, or about, the site or the operations of other Contractors.

1.24.8 Empty cable drums shall be removed promptly from the site and, in any case, not more than seven days after the cable has been removed from them. At no time shall more than three empty drums be stored on site unless the Contract Administrator has agreed otherwise.

1.24.9 Each drum shall contain only one piece of cable. Where two or more short lengths of cable of the same type and size are required, they may be delivered to site in one length for cutting on site. Long cables shall be delivered in one piece wherever this is possible within the limitations as to drum size imposed by the facilities for delivery, access to the site and subsequent handling.

1.24.10 Delivery documentation shall show clearly the drum reference numbers and the reference numbers, from the Drawings or Cable Schedules, of the cable that each drum contains.

1.24.11 During installation, cables shall not be allowed to be bent to a radius less than that specified in the relevant British Standard and herein.

1.24.12 All cables shall be pulled into position in such a manner as to avoid any damage whatsoever to the cable or its sheath. Cables shall, wherever possible, be pulled directly from the top of the drum, which shall be supported throughout the operation in such a manner that it is completely free to rotate.

1.24.13 Where the circumstances of the cable route make the removal of the cable from the drum before pulling into position unavoidable, the cable shall be laid out neatly on a smooth clean area of ground completely free of debris or anything likely to cause damage to the cable.

1.24.14 In such cases, 'figure eights' shall be avoided and the greatest care shall be taken to avoid subjecting the cable to twisting.

1.24.15 An adequate number of cable rollers, each of which shall be undamaged and completely free to rotate, shall be used to support the cable during pulling, in such manner that no part of the cable can touch the ground, the trench bottom or sides, or the walls of buildings. Cables shall not be dragged over concrete or other surfaces.

1.24.16 The number and positioning of rollers at bends in the route shall be such as to ensure that the minimum bending radius for the cable is not approached.

1.24.17 Cables shall, wherever possible, be pulled into position by hand, using an adequate number of operatives suitably positioned along the length of the cable. Winches, whether power driven or hand operated, and other mechanical aids shall only be used with the prior authorisation of the Contract Administrator which shall only be given in particularly difficult circumstances.

1.24.18 Cables which are intended to be winched into position shall be fitted by the manufacturer with a suitable pulling eye, firmly attached to all of the conductors, before being dispatched to site.

1.24.19 Whenever a winch or similar appliance is used, an approved tension gauge shall be fitted into the haulage line between the winch and the cable. The pulling tension shall at all times be within the limit advised by the cable manufacturer, which shall be communicated in writing to the Contract Administrator before the operation is commenced.

1.24.20 Cable stockings, when used, shall be of an approved pattern and the correct size, with swivel eye, in perfect condition, and shall be fitted with care to avoid damage to the cable sheath. When a cable stocking has been used on sheathed cable and the sheath, after removal of the stocking, shows signs of having been stretched, the cable shall be left for 30 minutes to recover. At the end of this period, if the sheath has not completely returned to its original position, the cable ends shall be cut back by an amount equal to the length of the stocking plus 300mm, then immediately released.

1.24.21 During the course of pulling operations, the cable shall not be allowed, under any circumstances, to twist or rotate about its longitudinal axis as a result of excessive pulling tension or for any other reason.

1.24.22 Whenever the length and arrangement of a cable run are such that excessive tension would be likely to be needed to nose-pull the cable into position, the continuous bond method shall be employed, using a wire pulling bond equal in length to twice the cable length, to which the cable shall be securely attached at intervals not greater than 1.8 metres.

1.24.23 Snatch blocks shall be used at bends in the run to ensure that the pulling tension is taken by the block and not by the cable.

1.24.24 Whenever a cable is cut, for whatever reason, the cut ends of both portions shall be immediately re-sealed. Armoured cables shall be sealed by means of an approved plastic cap embracing the armour wires and outer sheath. No other form of temporary capping shall be accepted.

1.24.25 All cables shall be secured by non-combustible fixings at regular intervals.

1.25 Protection

1.25.1 The Contractor shall take all necessary precautions to prevent damage to cables during installation.

1.25.2 Where cables are installed in situations where works by other Contractors are still incomplete, the Contractor shall take all reasonable precautions to protect the cables against damage arising from the execution of such other works.

1.25.3 Any damage to the outer sheath of a cable may be repaired, subject to the agreement of the Contract Administrator and provided that the materials and method used conform to the cable manufacturer's recommendations.

1.25.4 In the event of damage to the armouring or the inner sheath of a cable, or damage to a single insulated cable, such damage shall be immediately reported to the Contract Administrator who shall have the power to require a replacement length of cable to be installed.

1.26 Segregation of Services

1.26.1 Cables associated with individual services shall be segregated as set out below, unless specifically detailed otherwise elsewhere in this Specification or in the Contract Drawings.

1.26.2 Segregation of category 1, 2 and 3 circuits shall be provided as detailed in Section 528 of the IEE Regulations, together with BS 5266, BS 5839, BS 5588 and BS 6701 as appropriate.

1.26.3 All cables shall be separated from water, gas and other piped services by a distance of not less than 150mm unless the circumstances of the installation make this impossible. In such a case, the proposed cable route shall be agreed with the Contract Administrator.

1.26.4 All cables shall be installed in such a manner that any cable may subsequently be removed without disturbing the remainder of the group or any other existing or foreseeable services, unless otherwise detailed elsewhere in this Specification or in the Contract Drawings.

1.26.5 Segregation arrangements shall be as follows:

1.27 LV Cables

1.27.1 All cables operating at voltages between conductors or to earth of between 50 and 1000V AC shall be segregated as follows:

- From HV services - minimum distance 300mm
- From ELV services - minimum distance 300mm

1.27.2 For the purposes of this Clause, 110/55V fixed wiring for portable hand tools and similar purposes shall be treated as LV services. It shall however be routed via dedicated containment systems where wired using single insulated cabling.

1.28 ELV Cables

1.28.1 All cables operating at less than 50 AC between conductors or to earth, other than as specified above, shall be segregated as follows:

- From HV services - minimum distance 750mm

1.28.2 From LV services - minimum distance 300mm

1.28.3 This clause shall also apply to all UHF and VHF aerial cabling, alarm systems, control wiring, induction system aerials, etc. The Contractor shall obtain from the system specialist his detailed requirements in respect of segregation, and where these are at variance with the foregoing the most onerous condition shall be met.

1.28.4 ELV cables for different systems shall be segregated from one another as required by the systems specialists, to ensure that there is no signal induction, attenuation or other form of interference.

1.29 Essential Services

1.29.1 All cabling associated with essential services, such as (but not limited to) fire alarms, sprinkler equipment, emergency lighting, fire-fighting generators, fire-fighting lifts, smoke extraction plant etc., shall be run segregated from other services, generally as detailed above. All cabling shall be routed via independent support or containment systems.

1.29.2 Duplicate supplies for essential plant shall be routed via independent support/containment systems, which shall utilise separate risers, cable-ways, etc. throughout their length. At common points, such as adjacent to connections to essential plant, cabling shall be segregated by a minimum distance of 1000mm as far as is possible.

1.29.3 The routing and segregation of all essential services cabling shall be subject to the detailed approval of the Contract Administrator, and where appropriate the District Surveyor.

1.30 Testing

1.30.1 Each and every cable installed shall be subject to a full set of testing, as prescribed within Guidance Note 3 of the IEE Regulations. Every cable shall appear on the test charts appended to the Completion Certificate, as detailed elsewhere in this Specification.

1.30.2 All mains and sub-mains cables shall be subjected to acceptance tests at the manufacturer's works immediately prior to dispatch to site. These tests shall include, as a minimum, the following in accordance with the relevant British Standards:

- Measurement of conductor resistance
- Measurement of capacitance
- Measurement of insulation resistance
- Pressure test

1.30.3 Immediately after the works acceptance tests, both ends of every cable length shall be sealed. Plastic cables shall be sealed by means of a plastic cap embracing the armour wires and the outer sheath. Cable ends shall be marked in accordance with the relevant British Standard.

1.30.4 As soon as is practicable after the completion of installation and/or jointing of the cables specified herein, or of any usable group of such cables, the Contractor shall carry out the tests described below, together with such other tests and measurements as may be required by the Contract Administrator in order to prove compliance with this Specification and with the requirements of the IEE Regulations.

1.30.5 An insulation resistance test shall be carried out with a insulation resistance tester or other approved multifunctional testing instrument, to measure the insulation resistance between each conductor and the remaining conductors and between each conductor and the metallic sheath and armouring (if any). The test voltage to be applied shall be as follows:

- Low Voltage Cables (Above 500V) - 1000 volts
- Low Voltage Cables (50V to 500V) - 500 volts
- Extra Low Voltage Cables (less then 50V AC) - 250 volts

1.30.6 Extra-low voltage cables shall only be tested in strict accordance with manufacturer's recommendations.

1.30.7 The above tests shall be carried out both before and after second fixing and the insulation resistance shall not be less than the figures set out in BS 63461, Table 3, as amended April 1974, for all cables up to 3.3kV. Above this voltage, insulation resistance figures shall be agreed with the Contract Administrator.

1.30.8 Mineral insulated cables shall be subjected, on completion of installation and jointing, to a voltage test in accordance with the Appendices C of Parts 1 and 2 of BS 6207 for copper sheathed cables. The test voltage shall have the value tabulated in the appropriate Appendix and shall be applied for 30 seconds.

1.30.9 Where existing cables are to be incorporated into the works, the resistance test specified above may be carried out at a reduced voltage if the cable has been in service for more than five years. In such a case the test voltage shall be determined by applying a factor K to the value given in the appropriate British Standard as referred to above, and the value of K shall be as given in the following table:

1.31 Age of existing cable in years K

0 - 5	1.0
5 - 10	0.9
10 - 15	0.8
15 - 20	0.7
20 - 25	0.6
25 – 30	0.5

1.31.1 An earth continuity test shall be conducted on each cable to verify that the cable armouring or metal sheath, if any, has been properly bonded to earth, the test being carried out with an approved type of testing instrument.

1.31.2 Phase rotation and phase correspondence tests shall be conducted on each cable to prove that the cables have been correctly connected.

1.31.3 All tests shall be carried out in the presence of the Contract Administrator or authorised representative, to whom a minimum of fourteen working days' notice shall be given in writing.

1.31.4 The Contractor shall provide, at their own expense, all skilled and other labour, including supervisory and/or technical grades, and all apparatus, equipment and instruments necessary for carrying out the tests described above.

1.31.5 The Contractor shall be responsible for recording the results of all tests and measurements, and shall provide the Contract Administrator with four typed copies of a formal test report(s) embodying the said test results and measurements within seven days of each test.

1.32 Identification

1.32.1 All armoured cables, whether used as mains, sub-mains, final sub-circuits or control connections, shall be fitted with an external labels. Mains and sub-mains shall carry cable numbers and brief descriptions, i.e. "SM7, Level 1 Lighting" or "NE3, Lift No 3". Control cables shall carry reference numbers, arranged to coincide with schematic drawings. These requirements shall equally be applied to cables associated with essential services. Armoured cables used as final sub-circuits shall be labelled with their circuit references, and plant equipment supplies shall give the plant reference and a brief description, i.e. "P9, HWS Circulation Pump No 2"

1.32.2 In all cases, labels shall take the form of slip-over markers with indelible 2mm (minimum) high characters, on one or more carrier strips. Carriers shall be attached to each cable using 2 No black LSF cable ties, adjacent to each point of termination. Additionally, labels shall be fitted at 30m intervals along each cable length, or such lesser distance as may be required to allow accessibility.

1.32.3 HV cables shall be fitted with warning labels at 3m centres. They shall comprise slip over markers on carrier strips as previously specified, reading "Danger Nv" where N is the phase to phase voltage. Where run on high level support systems, engraved labels shall be fitted to the underside in plain view. They shall be white with 20mm high red characters reading "Danger Nv", as before.

1.32.4 All single insulated cables, where used as final sub-circuits, shall be labelled where terminated within distribution boards. This requirement shall also apply to the cores of other types of cable when used for this purpose, and also to circuit protective conductors. The cores of all control cables shall be numbered at each point of termination.

1.32.5 Labels shall comprise slip-over ferrules with 1mm (minimum) high indelible characters, giving the circuit reference or wire number of each conductor.

1.32.6 Should the Contractor wish to offer an alternative labelling medium, he shall do so at tender stage, indicating the saving available to the contract. A fully detailed technical description of the proposed alternative method shall be provided for consideration by the Contract Administrator.

1.33 Penetrations

1.33.1 All non-structural holes where cables pass through walls, floors, ceilings, partitions or the like, suitable holes shall be cut by the Contractor in liaison with the Main Contractor, who shall make good after the installation of the cables. The Contractor shall mark out accurately, at least 14 days in advance of the cable installation, the position of all such holes which are required to be cut by the Contractor or the Main Contractor. All holes shall be reviewed by the Main Contractor, Architect, Structural Engineer and Building Services Engineers, prior to their marking out on site, all penetrations shall be noted on the Contractors 'Builders Work in Connection' working drawings.

1.33.2 Where cables pass through walls, ceilings, partitions and the like, the Contractor shall provide and fix in position a heavy-gauge flame retardant plastic sleeve having an internal diameter greater by at least 12mm, but not more than 25mm, than the diameter of the associated cable. The length of any such sleeve shall be such that each end projects by 5mm beyond the surface of the element through which it passes, and the ends of the bore shall be free from burrs and provided with an adequate radius to prevent chafing of the cable sheath.

1.33.3 Where cables pass through floors, the Contractor shall supply and fix in position a heavy-gauge steel sleeve having an internal diameter greater by at least 12mm, but not more than 25mm, than the diameter of the cable and projecting above floor level by at least 50mm. The ends of the sleeve shall be smooth, as specified above.

1.33.4 Except where the Contract Administrator shall judge that the precaution is unnecessary, all cables rising from floor level shall be protected to a height of 0.6 metre by means of an approved proprietary galvanised sheet steel troughing having a thickness of not less than 1.0mm.

1.33.5 Where called for on the Contract Drawings, cables passing through walls or floors shall be provided with purpose made cable transfers comprising a rigid fixed frame with adjustable seals and a suitable clamping devices. Each transfer shall have 25% spare capacity for future cables.

1.33.6 Where cables pass through walls and/or floors which form part of the building's fire compartmentation, the hole(s) through which the cables pass shall be sealed in an approved manner, after the cables have been installed, so as to give the same standard of fire resistance as the original wall or floor.

1.33.7 All exposed cables shall be adequately protected against mechanical damage, from whatever cause, wherever a risk of such damage is likely to exist.

1.34 Cables Installed on Tray

1.34.1 Cables mounted on cable tray shall be installed in a neat and workmanlike fashion and shall be secured by non-combustible fixings at regular intervals. Unless detailed otherwise elsewhere in this Specification or on the Contract Drawings, cables shall be fixed as follows:

1.35 Horizontal Runs

1.35.1 Cables shall be supported from below and shall be fixed using black LSF cable ties. For cables up to a diameter of 25mm, ties shall be medium duty (width 6mm), while for larger cables heavy duty (width 9mm) shall be used. Ties shall be installed at spacing not exceeding 225mm for medium duty and 300mm for heavy duty, and at all changes of direction. In all cases, fire resistant cable ties shall be installed at a minimum of 1m intervals to provide cable support in the event of a fire.

1.36 Vertical Runs

1.36.1 Not exceeding 3.5m, cable shall be fixed as detailed for horizontal runs. For vertical runs in excess of 3.5m, fixings shall be as follows:

- Cables up to 25mm diameter - Heavy duty cable ties as previously detailed, at spacing not exceeding 225mm.
- Cables in excess of 25mm diameter - individually fixed using two part aluminium claw cleats at spacing not exceeding 300mm. Cleats shall be fixed using sheradised steel hexagon head set screws and fullnuts, of the maximum size admitted by the fixing hole in the cleat. Setscrews shall be cut down such that they do not protrude above the face of the fullnut, and shall be filed smooth and immediately treated with a cold galvanising agent.

1.37 Generally

1.37.1 Essential Services Cables shall in all instances be fixed using stainless steel cable ties, sized and spaced as described above for horizontal cable runs.

1.37.2 All LSF cable ties shall be coloured black and shall be UV-stabilised and suitable for external use. They shall comply with UL 1565, and shall be fitted using a purpose-made tensioning tool.

1.37.3 Cables for power circuits (i.e. any circuits connected to current consuming equipment) shall be installed flat, touching but not banked, unless detailed otherwise elsewhere in this Specification or on the Contract Drawings. Cables for control purposes may be banked, but not more than 50mm deep. In all instances, a neat and tidy installation shall be provided with no cable crosses, interweaving or snaking.

1.37.4 Three-phase groups of single-core cables carrying alternating current shall generally be laid in trefoil formation and touching each other. Where this is not possible the disposition to be adopted shall be agreed with the Contract Administrator before installation is commenced.

1.37.5 All cable trays shall have a minimum spare capacity for future cabling of 25%. Cabling shall be such that a clear route is available for future works.

1.37.6 Where cables peel off trays to connect to distribution boards, control panels, etc., they shall do so in strict order such that no crosses occur. The maximum length of unsupported cable between tray and equipment shall be 300mm.

1.37.7 Where mineral insulated cables are run on cable tray, they shall be fixed using P-clips (for individual cables) or copper fixing strap for multiple runs. In all cases, brass cheesehead setscrews, fullnuts and washers shall be employed. They shall be of the largest size admitted by the clip hole, subject to a minimum of M4. Fixing spacing shall be as detailed above.

1.37.8 Unsheathed mineral cables shall not be installed on galvanised tray.

1.38 Cables Fixed to Structure

1.38.1 Single cable runs shall be clipped direct to the structure, where shown on the Contract Drawings or detailed elsewhere in this Specification. Where multiple cable runs occur, cable tray/trunking/rack, etc. shall be employed, as specified.

1.38.2 Due allowance shall be made for the operating temperatures of cables and the combustibility of the surfaces on which they are fixed.

1.38.3 Cables up to 25mm diameter shall be fixed using non flame propagating black nylon cleats, fixed using sheradised roundhead woodscrews of the maximum size admitted by the fixing hole of the cleat. To ensure integrity during fire conditions, steel cable cleats are to be installed every 1m unless the cables is otherwise supported.

1.38.4 For larger cables, two part aluminium claw cleats shall be employed, fixed as detailed above. Alternative fixing methods such as rawlbolts, expanding anchors or similar, shall be employed as dictated by the weight of the cable, with a suitable additional allowance for overloading resulting from abuse as detailed elsewhere in this Specification.

1.38.5 Fixing spacings shall be a maximum of 225mm for cables up to 25mm diameter, and

1.38.6 300mm for larger sizes. Additional fixings shall be provided as required to prevent deflection and maintain a neat and tidy appearance, and at all changes of direction.

1.38.7 All cables shall run parallel to building lines, and all cleats shall be correctly sized such that they hold the cable securely without damage to the sheath.

1.38.8 Notwithstanding the foregoing, it shall be the responsibility of the Contractor to ensure that all cables are adequately supported. Where necessary, structural steelwork shall be provided to support cables, and this shall comprise a preparatory system of 40 x 40mm galvanised channel and associated accessories.

1.38.9 Where cables are to be carried on structural steelwork, the cable supports shall be attached to the steelwork by means of approved girder clips or other patented attachment devices not requiring drilling of the steelwork. Welding of cable supports to structural steelwork shall be subject to the approval by the Contract Administrator, whilst drilling of the steelwork for the attachment of cable supports shall not be permitted.

1.38.10 Where cables run above ground are required to cross open spaces, of a length exceeding the normal permitted support spacing, and no structure is available on which to fix cable supports, the Contractor shall supply and install suitable fabricated steel auxiliary structures to support the cables.

1.38.11 Any auxiliary steel structures required shall be designed in accordance with BS 449 and fully detailed drawings and calculations shall be submitted to the Contract Administrator for verification and approval before any work is put in hand. In each such case, an allowance of 25% shall be made in the design for future additional cables.

1.38.12 All auxiliary steel structures shall be securely bonded to earth.

1.39 Mineral Insulated Cables

1.39.1 Mineral insulated cables shall be installed as detailed under the Clauses describing particular installation methods elsewhere in this Specification.

1.39.2 All mineral insulated cable shall be installed by suitably qualified and experienced engineers. All cable shall run neat and true, free from bends, twists and other deflections along its length. Where cables have been subject to bending during installation, a cable straightener shall be employed to produce an aesthetically acceptable finish.

1.39.3 Where the PVC or LSF oversheath of a cable is damaged during installation, it shall be repaired or replaced as directed by the Contract Administrator.

1.39.4 All cables shall be fixed using purpose-made clips as detailed elsewhere in this Specification. Individual cables shall be fixed using copper P-clips, with oversheath to match the cable. Multiple runs shall employ copper band as above, with all cables dressed in a workmanlike fashion. Cables shall not be 'tram railed', nor shall more than one clip be attached by a single fixing.

1.39.5 Cable terminations shall be made by specialist engineers, using compression type pots and seals, with brass glands and locknuts and LSF shrouds. Terminations shall be made using pot wrenches, in clean, dry conditions such that the finished terminations are free from contaminants.

1.39.6 In all cases, MICC cable terminations shall exhibit phase to phase and phase to earth resistances of not less than 50 Mohms when tested using a 1000v insulation and resistance tester. Cable terminations shall be subject to retesting at the direction of the Contract Administrator, without cost or delay to the Contract.

1.39.7 All individual cores shall be fitted with black neoprene oversheaths. For cables with one to four conductors, phase-coloured insulation tape shall be fitted to each core. For larger numbers of conductors, cores shall be fitted with numbered ferrules.

1.39.8 In all cases, cables shall be made off with tails of sufficient length to reach equipment terminals directly without intermediate connectors.

1.39.9 The dressing and termination of mineral cables shall be subject to the detailed approval of the Contract Administrator. In particular, cables terminating at a common position shall be dressed identically such that a neat installation is achieved. The maximum distance spanned by an unsupported MICC cable shall be 300mm for cables of overall diameters up to 15mm, and 450mm for larger sizes.

1.39.10 Where cables terminate at equipment subject to vibration or movement, anti-vibration loops shall be provided. They shall be of 300mm diameter for cables of diameter up to 15mm, and 450mm for larger sizes. Cable loops shall be self-supporting, without intermediate fixings.

1.40 Cables Installed in Conduit/Trunking

1.40.1 Cables installed in conduit and/or trunking shall be fed into the containment system from cable drums mounted on a drum rack or similar, such that cabling is kept clean of the ground at all times and is free from twisting.

1.40.2 The maximum number of cables drawn into any one conduit or trunking shall not exceed those allowed by reference to Appendix A of Guidance Note 1 of the IEE Regulations. Where cables are used which are not referred to in the Guidance Note, the manufacturer's recommendations shall be obtained in writing and strictly adhered to.

1.40.3 Sufficient personnel shall be provided to ensure that cables are drawn into containment systems without chafing on trunking lips, etc. and without the use of excessive pulling force. Mechanical pulling devices shall not be employed. The use of lubricants shall be subject to the approval of the Contract Administrator. Such lubricants shall be purpose made, water based, soluble, non-toxic and odourless, shall be non-staining, temperature stable, non-ageing and producing non-combustible residue.

1.40.4 Each mains voltage circuit wired using single core cables drawn into a containment system shall be complete with a dedicated circuit protective conductor (CPC). Where no cable sizes are specified, they shall be selected in accordance with table 54G of the IEE Regulations subject to maximum and minimum sizes of 50mm²and 1.5mm² respectively.

1.40.5 Cables within conduit/trunking shall be of sufficient length that slack is provided within the containment system. Where single core cables are installed within trunking systems, they shall be taped together in bundles comprising the phase, neutral and protective conductors of each individual circuit at 2m intervals using uPVC insulation tape.

1.40.6 Where mineral cables are routed through conduits (drops to fire alarm breakglasses, etc.) cables shall be glanded where they enter the conduit. The cables shall extend to the accessory back box, where they shall be made off using an earth-tail pot and seal.

1.40.7 Where flat profile cables such as 6242Y or similar are run through containment systems, care shall be taken to prevent twists. A maximum of 2 No flat multicore cables shall be routed via a single conduit.

1.40.8 No cables shall be installed until the entire containment system is complete for their full length. All new cables within an individual conduit shall be installed as a single operation. Where an existing conduit and cable system is to be amended or extended, the Contractor shall ensure that the existing cables are suitably protected such that they are not damaged as new cables are drawn in.

1.40.9 The Contractor's attention is drawn to the requirements for segregation of services detailed elsewhere in this Specification. In the case of LV or ELV services, the requirements shall be deemed to have been met where cabling is installed in different compartments of a trunking provided with metallic separators throughout its length.

1.41 Joints and Terminations

1.41.1 The Contractor shall supply and install all materials, equipment and accessories necessary for the proper jointing, terminating and connecting, ready for service, of all cables included in the works, unless otherwise detailed on the Contract Drawings.

1.41.2 Cable joints shall only be permitted under exceptional circumstances, with the written permission of the Contract Administrator. This shall generally be in situations where cables are unavailable in sufficient lengths to meet site requirements.

1.41.3 Where cables are damaged on site, the decision as to whether to provide a joint or replace the cable entirely shall rest solely with the Contract Administrator.

1.41.4 Under no circumstances whatsoever shall joints be permitted in essential services cables. Joints and terminations of cables shall only be made by competent cable jointers approved by the Contract Administrator. Before employing any such operative on work of this kind, the Contractor shall provide the Contract Administrator with full details of his or her training and experience and, if required, arrange for the person to perform a trade test to be witnessed by the Contract Administrator. The Contract Administrator shall have the right to withhold approval of any operative if they are not satisfied as to the person's competence, or to direct the Contractor to employ the cable manufacturer's personnel or such other qualified persons as the Contract Administrator may decide.

1.41.5 All joints and terminations, once commenced, shall be completed and sealed in the shortest possible time, without interruption. No joints or terminations, other than those above ground inside a dry weatherproof building, shall be commenced without the prior authority of the Contract Administrator, who shall require to be satisfied as to the conditions under which the work is to be carried out. No joints shall be made under wet or dirty conditions. All outdoor jointing, even in dry weather, shall be carried out under the protection of an approved type of tent or other shelter, and the Contract Administrator shall have the right to prohibit the commencement of outdoor jointing work if he is not satisfied that acceptable weather conditions shall prevail for a sufficient length of time to enable the work to be completed.

1.41.6 The positions of all joints shall be clearly marked on all layout and schematic drawings. Cables shall be identified at joint positions using external markers as detailed elsewhere in this Specification.

1.42 Cable Joints

1.42.1 Cable sealing compounds shall comply with BS 1858 and shall be of a type approved by the cable manufacturer. A tropical grade compound shall be used in locations where the normal ambient temperature is likely to exceed 30°C, and an oil-resisting compound where the difference in level between the ends of the cable exceeds 6 metres.

1.42.2 Care shall be taken to ensure that sealing compounds are poured at the correct temperature. Compound levels shall be checked and topped up after cooling.

1.42.3 Compound filling shall be carried out in stages to allow time for the material to flow. Under no circumstances, however, shall the compound be allowed to cool during the process, to the point where re-heating is necessary.

1.42.4 The Contractor shall submit to the Contract Administrator, for approval, fully detailed drawings of the intermediate joint boxes that he proposes to supply, together with a full jointing specification.

1.42.5 All tee and other branching joints shall be made with the main cable unbroken, except in the case where a separate straight through joint would otherwise be required immediately adjacent to a branching joint.

1.42.6 Cables in straight through joints and, where the procedure is allowable under the preceding clause, main cables in tee and other branching joints shall be jointed core-to- core without crossing.

1.42.7 When separate lengths of cable are to be joined, care shall be taken to ensure that an 'A' (or red) end is laid next to a 'Z' (or green) end.

1.42.8 Where an existing cable is to be cut into and extended, either the two new lengths of cable shall be pulled into position in opposite directions or one length shall be drummed in the reverse sense, so that the ends of the new cables can be matched with the cut ends of the existing cable without the necessity for a 'crossed-core' joint.

1.42.9 All intermediate joints shall be offered for inspection by the Contract Administrator before closing and filling.

1.42.10 Intermediate joints on plastic and elastomer insulated cables shall be made in a joint box of the type recommended by the cable manufacturer incorporating an inner box with provision for making a watertight seal on to the inner sheaths of the cables and an outer cast iron box with provision for making a watertight seal on to the outer sheaths of the cables, for clamping the cable armouring, and for binding the armour across the joint.

1.42.11 Where intermediate joints are necessary on mineral insulated cables used as mains cables, they shall be made within galvanised malleable iron adaptable boxes of suitable size fitted with glands and fixed base mechanical clamping connectors of approved design.

1.42.12 Where such joints are to be made out-of-doors or underground, the box in which the joint is made shall be enclosed in a second larger, galvanised box, also fitted with glands, and the outer box shall be filled with an approved jointing compound.

1.42.13 Where a new cable is to be jointed to an existing cable, the following procedure shall be adopted before any work is done on the existing cable.

1.42.14 The Contractor shall obtain from his competent Authorised Person an official permit to work, as detailed elsewhere in this Specification.

1.42.15 The existing cable shall be positively identified to the satisfaction of the Contract Administrator.

1.42.16 Any switch or circuit breaker through which the cable can be made alive shall be locked in the 'earthed' position if one is available, otherwise in the 'off' position. The Contractor shall provide suitable padlocks for this purpose if none is available.

1.42.17 If the switch or circuit breaker has no 'earthed' position, the cores of the cable shall be earthed by other approved means, as agreed with the Contract Administrator.

1.42.18 If the cable forms part of a system normally supplied at a pressure in excess of 55 volts to earth, it shall be 'spiked' by an approved method.

1.42.19 Immediately after the cable is cut or, if it is not to be cut, after removing the core insulation, the insulation resistance of the cable, or both parts of it, shall be measured in the presence of the Contract Administrator with an approved testing instrument and the result(s) recorded.

1.42.20 Whenever a connection is to be made to an existing system which is already in operation, the work shall be programmed so as to cause the minimum of inconvenience to the user of the existing installation. A detailed programme shall be submitted in writing to the Contract Administrator for approval, and no work shall be commenced until such approval has been given in writing. Once approved, the programme shall be strictly adhered to.

1.42.21 Proprietary jointing techniques based on non-traditional materials and procedures shall be considered for acceptance provided that fully detailed technical descriptions and/or illustrations and/or samples of the components, materials, or techniques to be used are submitted to the Contract Administrator for approval not less than 28 days before it is intended that they be used, so as to give adequate time for evaluation of the proposals.

1.42.22 If the proposed jointing or terminating procedures involve the use of heat-shrinking materials or other materials requiring the exercise of unusual or novel skills, the Contractor shall demonstrate, to the complete satisfaction of the Contract Administrator, that the operatives who shall be employed on the work have acquired the necessary skill(s). The Contractor shall cease, forthwith, to use such materials if the Contract Administrator shall decide that the procedures are not being carried out to his satisfaction.

1.43 Cable Sockets

1.43.1 Cable sockets, lugs and ferrules shall be of the correct size for the cables with which they are to be used.

1.43.2 Cable sockets, lugs and ferrules shall be of either the sweating type or an approved crimping type used in conjunction with an approved crimping tool as specified.

1.43.3 Sweating type sockets for conductors of 70mm² and larger shall be of cast brass, machined.

1.43.4 If solderless cable lugs and ferrules are to be used on cables with copper conductors, they shall be hot-pressed from high conductivity copper to BS EN 13601 or forged from copper tube to BS 1172, and shall be electro-tinned or dip-tinned.

1.43.5 Solderless cable sockets, lugs and ferrules for use with aluminium conductors shall be made from electrical quality aluminium.

1.43.6 All solderless cable sockets, lugs and ferrules shall be sourced from an approved manufacturer, and shall be installed using crimping tools of the same manufacture, strictly in accordance with the manufacturer's recommendations. The completed connections shall, in every case, meet the performance requirements of BS 4579.

1.43.7 Unless otherwise recommended by the cable manufacturer or the joint or jointing system manufacturer, solder shall be an alloy of tin and lead, with or without the addition of antimony, conforming to BS EN 29453. Alloy grade H (35% tin, 65% lead) shall be used for the plumbing of lead and lead alloy cable sheaths, and alloy grade F (50% tin, 50% lead) for general work on copper conductors.

1.43.8 For the soldering of fine connections, and in situations where damage or overheating may easily be caused, grade K (60% tin, 40% lead) or grade A (64% tin, 36% lead) alloys shall be used. Joints in heavily loaded copper cables shall be made with pure tin (grade T3) when required by the Contract Administrator.

1.44 Glanding of Cables

1.44.1 Wherever cables are glanded off within items of switchgear, control panels, etc. the inner sheath or serving shall remain intact from the gland to a point adjacent to the equipment terminals.

1.44.2 Where used in external positions or other situations subject to wash down, etc. all cables shall be glanded off into the bottom face of items of switchgear or equipment. The Contractor shall ensure that the IP-rating of such equipment is not reduced upon installation.

1.44.3 Cable glands, locknuts, shrouds, earthtags and bonding arrangements shall be as detailed elsewhere in this specification for individual cable types. They shall be installed in strict accordance with the manufacturer's recommendations.

1.44.4 Where the equipment to which the cables are to be connected is supplied with blank un- drilled gland plates, the Contractor shall drill all necessary holes for fitting the glands.

1.44.5 Where multiple cables are made off into glandplates, they shall be spaced such that it is possible to remove any individual gland without effect on its neighbours. Space shall be allowed to accommodate a future additional 25% increase in cable numbers, and this shall be co-ordinated with the spare capacity on associated support systems as detailed elsewhere in this Specification.

1.44.6 Cables shall wherever possible to made off into threaded entries. Where such entries have non-standard threads, purpose made adapters shall be employed, manufactured from the same material as their associated cable gland.

1.44.7 All cable glands, adopters, locknuts, etc. shall be tightened in line with their manufacturer's recommendations, using appropriate tools. It shall not be acceptable for any impact methods to be used in this regard.

1.45 Sub-Circuit Configurations

1.45.1 Unless specifically detailed otherwise herein or on the Contract Drawings, the topography of final sub-circuits shall be as follows:

- Lighting, single core cables - radial circuits following the 'loop-in' principle, with no joints other than at the terminals of equipment.
- Lighting, multi-core cables - radial circuits following the 'three-plate' principle, with all joints made at purpose made terminals within luminaires. Junction boxes and neutrals at switch positions shall not be permitted.
- Socket Outlets - ring circuits without crosses or spurs.
- Fixed Power - radial circuits, extending directly from the protective device to the equipment terminals.

1.45.2 All of the forgoing sub-circuit configurations shall comply with the definitions and general arrangements given under the current edition of the IEE Regulations.

1.45.3 All final sub-circuits shall be provided with continuous, dedicated circuit protective conductors. Where single core cables are used, CPCs shall comprise yellow and green conductors of the same type as the phase conductors. Unless detailed otherwise in this Specification or on the Contract Drawings, CPCs shall be sized in compliance with table 54G of the IEE Regulations, subject to a minimum size of 1.5mm^2.

1.45.4 Where multi core cables are employed, one core shall be used as the CPC (unless detailed otherwise elsewhere in this Specification or on the Contract Drawings). Where such cables provide a metallic armouring or sheath, this shall be connected in parallel with the CPC. All CPCs forming a core of a multi core cable shall be fitted with green and yellow sleeving wherever exposed.

1.45.5 Conduit - Types

1.45.6 General

1.45.7 All conduit and associated fittings and accessories shall comply fully with the detailed requirements set out below. Each type of conduit and fitting shall be selected from the range of a single manufacturer.

1.45.8 Steel Conduit and Accessories

1.45.9 All steel conduits, conduit fittings and boxes shall, unless detailed otherwise in this Specification or on the Contract drawings, be enamelled or hot dip galvanised. They shall comply with BS EN 61386-1 or BS 31 Steel Conduit and fittings for Electrical Wiring, as appropriate. The conduits shall be made by a manufacturer holding the appropriate British Standard Institution licence for the conduits specified.

1.45.10 Conduits shall comply with ASTA publication No 29, where applicable.

1.45.11 All steel conduit shall be Heavy Gauge Welded Steel, class 2 for black stove enamelled and class 4 for hot dipped galvanised finish.

1.45.12 If the type of finish is not particularly detailed elsewhere in this Specification or on the Contract Drawings, the type shall be determined as follows:

- External locations, cast into concrete, surface mounted in plantrooms or similar, or in other locations subject to continuous or occasional damp conditions - Galvanised finish.
- In other locations - Black Enamelled finish.
- All conduit shall be provided in 3.75m lengths, with each end pre-threaded at works. Screwed circular conduit boxes shall generally be constructed from malleable cast iron, with either black stove enamelled or hot-dipped galvanised finish. Alternatively, boxes may be manufactured from high quality 14 gauge cold reduced mild steel (grade 1), with finishes as previously detailed.
- Conduit fittings, boxes, etc. of aluminium or other alloy shall not be used unless specifically required by the Contract Administrator.
- Standard 50mm centre circular boxes complete with earth terminals shall be used except at switches and accessory outlets where special boxes may be required, or where adaptable boxes are specified.
- Adaptable boxes shall have dimensions of not less than 100 mm x 100 mm x 37 mm. Not more than three 20mm conduits shall be permitted to enter the box, and where more or larger conduits are to be accommodated larger boxes shall be used. They shall be constructed from high quality 14 gauge cold reduced mild steel (grade 1), with finishes as previously detailed. They shall be plain (without knock-outs), and shall be fitted with brass earthing studs.
- All adaptable boxes shall be complete with lids. Where adaptable boxes are flushed in walls and ceilings the lids shall overlap the box on all sides.
- All galvanised finish boxes shall be provided with neoprene gaskets. Box covers shall be fixed by brass roundhead or cheesehead screws.
- Bushes for use with steel conduits shall be brass, unless otherwise specified. For connection to adaptable boxes, switch boxes, trunking, etc., they shall be male hexagon head smooth bore. Where used for cables to exit from the conduit system, they shall be female, with conduit thread of the appropriate length.
- Where conduits abut to trunking, or at surface-mounted equipment or adaptable / switchbox positions, flanged couplers and lead washers shall be employed.
- Inspection fittings and solid drawn bends/elbows shall not be employed without the specific approval of the Contract Administrator.
- Saddles shall generally be of the spacer-bar pattern. Where specified, distance saddles (giving 6mm clearance between conduit and wall) or hospital saddles (giving 12mm) shall be employed. Lambeth and clip-type saddles shall not be used.
- Male hooks shall be of malleable cast iron with 20mm threads, and galvanised or enamelled to match the local installation. Jackchain shall be single unwelded, minimum size 10, finished as above.
- Where fixing to exposed structural steelwork, purpose-made fixings shall be employed which do not require any drilling or welding of the structure. All such fixings shall be subject to the approval of the Contract Administrator.

1.45.13 Flexible Conduit

1.45.14 Flexible conduit shall be watertight and oil tight flexible metal conduit having an overall LSF sheath complying with BS 731, "Flexible steel tubing to enclose flexible drives for power driven tools for general purposes".

1.45.15 It shall be impervious to attack by lubricating oils, greases and sea water, and shall comply with BS 6401, NES 3 issue 3, and UL 94-VI in respect of smoke propagation and toxicity.

1.45.16 Each flexible conduit shall incorporate a 649X/7 circuit protective conductor of minimum size 2.5 mm² run internally within the flexible conduit from an earth terminal in the equipment.

1.45.17 Flexible conduit glands shall comprise fixed (non-swivel type) alloy assemblies, with standard metric threads. Where a weatherproof installation is called for elsewhere in this specification or on the contract drawings, glands shall be IP67 rated or better. In other cases, glands shall be IP54.

1.45.18 In all cases, flexible conduits shall be suitable for the following minimum bending radii:

Conduit Size	Min. Bending Radius
20mm	75mm
25mm	100mm
32mm	125mm

1.45.19 All flexible conduits shall meet the crush resistance and operating temperature range criteria set out in BS 731: Part 3, and flexible conduits without steel reinforcement shall not be employed.

1.45.20 Plastic Conduits and Accessories

1.45.21 All plastic conduits, conduit fittings and boxes shall be high impact PVC-U extrusions to comply with BS 4607 and BS 6099, as appropriate. The conduits and accessories shall be made by a manufacturer holding the appropriate British Standard Institution licence for the conduits specified.

1.45.22 If the type of finish is not particularly detailed elsewhere in this Specification or on the

1.45.23 Contract Drawings, the type shall be determined as follows:

- External locations, cast into concrete, surface mounted in plantrooms or similar, or in other locations not normally visible to the casual observer - black finish.
- In other locations – white finish.

1.45.24 Circular conduit boxes shall generally be constructed from high-impact PVC-U, with either black or white finish.

1.45.25 Conduit fittings, boxes, etc. of alternative material shall not be used unless specifically required by the Contract Administrator.

1.45.26 Standard 50mm centre circular boxes complete with earth terminals shall be used except at switches and accessory outlets where special boxes may be required, or where adaptable boxes are specified.

1.45.27 Adaptable boxes shall have dimensions of not less than 100 mm x 100 mm x 37 mm. Not more than three 20mm conduits shall be permitted to enter the box, and where more or larger conduits are to be accommodated larger boxes shall be used. They shall be plain (without knock-outs), and shall be fitted with brass earthing studs. All adaptable boxes shall be complete with lids. Where adaptable boxes are flushed in walls and ceilings the lids shall overlap the box on all sides.

1.45.28 All external boxes shall be provided with neoprene gaskets. Box covers shall be fixed by brass roundhead or cheesehead screws.

1.45.29 Inspection fittings and solid drawn bends/elbows shall not be employed without the specific approval of the Contract Administrator.

1.45.30 Saddles shall generally be of the spacer-bar pattern. Where specified, distance saddles (giving 6mm clearance between conduit and wall) or hospital saddles (giving 12mm) shall be employed. Clip-type saddles shall not be used.

1.45.31 Where fixing to exposed structural steelwork, purpose-made fixings shall be employed which do not require any drilling or welding of the structure. All such fixings shall be subject to the approval of the Contract Administrator.

1.46 Conduit Installation Methods

1.46.1 General

1.46.2 The Contractor shall determine all conduit sizes and detail all conduit routes on working drawings as described elsewhere in this Specification. The Contractor shall be responsible for co-ordinating the conduit routes and location of conduit boxes, including any conduit layouts that may be detailed on the Contract Drawings, with other trades.

1.46.3 No conduit smaller than 20mm diameter shall be installed.

1.46.4 Surface conduits shall harmonise with the architectural features of the building. They shall be run only in vertical and horizontal directions except where it is desirable to follow the line of a constructional feature, in which case the approval of the Contract Administrator shall be obtained prior to commencement. Wherever possible, they shall be located in secondary rooms and stores rather than in the main areas.

1.46.5 In multiple runs, crossing of conduits shall not be permitted. Where a surface conduit turns through a wall a back outlet box shall be provided.

1.46.6 Concealed conduit work in concrete or composite slabs, walls, cast in-situ and in plaster shall be offered to the Contract Administrator for inspection prior to concealment. The Contractor shall give the Contract Administrator seven days' notice, in writing, that a reasonable section of concealed conduit work shall be ready for inspection. This period may be reduced to forty eight hours if a Resident Engineer is employed by the Contract Administrator.

1.46.7 Where distribution boards are connected to trunking by conduits, the capacity of the conduits shall be sufficient to carry as many sub-circuit cables as there are ways in the distribution board. The supply cables feeding the distribution board shall be run in separate conduit.

1.46.8 Upon completion of the works, each and every conduit box shall be fitted with an appropriate lid, and all fixing screws shall be in place.

1.46.9 Immediately on completion of erection of each conduit run, all exposed open terminations shall be plugged effectively against the entry to foreign solids and liquids. Where concrete is to be poured seals of polystyrene waste shall be used. All seals shall be maintained in good order until it is necessary to complete wiring and connection of fittings.

1.46.10 Conduits which terminate within buildings shall be sealed with a permanently plastic weatherproof sealing compound in conjunction with hardwood bushes to prevent the ingress of water, foreign matter and vermin. Any spare conduits and ducts shall be similarly sealed.

1.46.11 The whole of the conduit system in any particular section shall be complete, and immediately prior to the drawing-in of cables all conduits shall be "swabbed" to ensure that any moisture or brick dust, grit, etc. which may have gathered in the tubes is completely removed.

1.46.12 Prior to erection all burrs and sharp edges shall be removed from the conduit together with any dirt, oil or grit, which may be present. Every conduit end shall be carefully reamed prior to erection.

1.46.13 All conduits necessarily exposed to the weather during building operations shall be protected against ingress or moisture either by means of suitable brass stops or other means as the Contract Administrator may direct, and shall have their threads coated with petroleum jelly.

1.46.14 Conduit boxes and fittings shall be fully protected in an approved manner to prevent the ingress of plaster, debris, etc. during the period of construction.

1.46.15 Immediately after the erection of steel conduit exposed screw threads and abrasions caused by tools and otherwise shall be coated with cold galvanising compound.

1.46.16 Conduit/conduit fittings shall be stored on site in such a manner that they are fully protected from mechanical damage and/or weather.

1.46.17 Conduit runs in damp situations shall be arranged to be self-draining to specific drain points which shall consist of BS boxes. Conduit runs shall not drain to boxes containing socket outlets or other electrical apparatus containing live terminations.

1.46.18 In conduit runs containing cables of size up to and including 4mm² a standard circular draw-in box shall be included, at not more than 8m intervals. For cables of sizes above 4mm² suitably sized adaptable boxes shall be installed in lieu of draw-in boxes to facilitate easy withdrawal of cables.

1.46.19 Conduit runs between draw-in boxes or adaptable boxes shall contain not more than two right angle bends (or the equivalent, made up from less acute angles). Bends in excess of 90°shall not be permitted.

1.46.20 The wiring shall be continuously and effectively protected throughout its whole length. All conduits shall be mechanically continuous, and no cables shall be installed in a system until it is complete. All steel conduits shall be electrically continuous.

1.46.21 Corners shall be turned by means of handmade bends or, where this is impracticable by means of conduit boxes. Factory made bends, tees and elbows and inspection tees and elbows shall not be used.

1.46.22 Expansion couplings shall be provided at positions where conduits cross building expansion joints. They shall be screwed one end, slip the other, and for steel conduits shall be cross bonded by means of 2 No BS 951 earthing straps and a short length of 4mm²6491X cable.

1.46.23 Conduits shall be installed with at least 150 mm clearance between them and gas, water, heating or other pipes except with express approval in writing of the Contract Administrator.

1.46.24 Where such permission is granted this shall imply that the necessary bonding of such services to the earthed metalwork of the electrical installation shall be made by the Contractor to ensure compliance with the IEE Regulations.

1.46.25 In addition to the above, conduits shall be installed at least 25 mm apart from each other where run in parallel.

1.47 Surface Mounted Conduits

1.47.1 All surface mounted conduits shall be installed in a neat and professional manner, and shall be subject to the approval of the Contract Administrator.

1.47.2 Where multiple runs or drops occur, care shall be taken with regard to aesthetic appearance. All saddles shall be in line, multiple bends shall match, etc.

1.47.3 Horizontal conduits on walls shall not be installed without the specific approval of the Contract Administrator.

1.47.4 Any damage to conduit finishes caused by vice jaws, etc. shall be made good, or conduits replaced at the direction of the Contract Administrator.

1.47.5 The use of running threads shall be kept to a minimum. Where runners are unavoidable, hexagon locknuts shall be used to lock couplers in position, and all exposed thread shall be immediately treated with a cold galvanising compound.

1.47.6 Drops to support suspended luminaires shall generally utilise fixed dome covers over circular conduit boxes. The soffit-mounted conduit system shall interconnect all support points, whether required for wiring purposes or not. Where the soffit is not horizontal, adjustable ball and socket units (with integral earth conductors where steel) shall be employed.

1.47.7 Where plug-in connections are specified for suspended luminaires, supports shall comprise hookplates, jackchain, male hooks and locknuts. Luminaire flexes shall be fixed to support jackchains using stabilised LSF cable ties.

1.47.8 Conduits within demountable ceiling voids shall be considered to be surface mounted for the purposes of this Specification. All such conduits shall be fixed to the soffit, not suspended below it on drop rods or similar. Where specific types of building construction limit the areas suitable for providing fixings (pot and beam ceilings, etc.) the Contractor shall co-ordinate his routes to suit the structural restrictions.

1.47.9 Steel conduits shall be supported at regular intervals as recommended by the IEE Regulations and the distance from either side of any box or bend to the nearest saddle shall not exceed 150 mm.

1.47.10 Saddles and distance pieces shall have the same finish as the conduit for which they are to be used, and shall be fixed by means of screws in metal, or approved plugs. Conduit boxes to which luminaires are to be attached shall be fixed by substantial screws such that the weight of luminaires shall not be carried by the conduit. Conduit runs in suspended ceiling voids shall be fixed to the building structure and not the ceiling.

1.47.11 Where ceilings are of the demountable tile type and capable of supporting recessed modular luminaires, the outlet boxes shall be fixed to the structure with a cable connection from the outlet box to the luminaire via plug-in ceiling rose, unless detailed otherwise elsewhere in this Specification or in the Contract Drawings. Where the luminaire is not of the modular type the outlet box shall be brought to the ceiling surface in the same manner as that for a fixed ceiling.

1.47.12 Within apartments, containments shall be installed within plastic containment such as conduit or trunking as agreed with the client.

1.48 Recess Mounted Conduits

1.48.1 Conduits shall be installed in wall chases and closed ceiling voids in such a manner that inspection and draw boxes are at accessible positions. Draw boxes shall not be fixed in plastered walls unless specifically agreed by the Contract Administrator.

1.48.2 Conduit buried in plaster shall be fixed by crampets and installed so as to allow a minimum depth of plaster of 12 mm over its entire length.

1.48.3 Where barium plaster is to be applied the conduit shall be covered by cement and boxes shall be built up to the edges with cement before plastering.

1.48.4 Extension rings shall be fitted to sunk conduit boxes to which luminaires fittings or pull switches are to be attached such that they finish approximately 2 mm below the finished wall surface.

1.48.5 In the case of wall mounted luminaires, conduits shall terminate in recessed circular conduit boxes with extension rings, accurately positioned to ensure co-ordination with luminaire cable entries and fixing holes.

1.48.6 Switchboxes shall be deep pattern, erected so as to be recessed approximately 2mm below the finished wall or ceiling surface and in order that this requirement is met, the finished thickness of all walls and ceilings shall be verified on site.

1.48.7 On flush installations with conduit drops only, conduits running vertically in walls shall protrude at least 50 mm into the ceiling space or floor void as applicable. Such steel conduits shall terminate using female brass bushes.

1.48.8 Where conduits are installed in demountable partitions, they shall be connected to the soffit or floor-mounted conduit/trunking network by means of short lengths of indoor type flexible conduit. A fixed through box shall be provided at either end of the flexible conduit, to facilitate wiring and earthing.

1.48.9 Where walls are to be tiled, associated accessory and equipment boxes shall be accurately aligned with tile joints (in respect of both horizontal and vertical axis). Generally wall elevations with tile setting out details shall be provided by the Contract Administrator to enable the Contractor to produce accurate working drawings.

1.48.10 Where the Contract Administrator has not made this information available prior to conduit installation commencing, the Contractor shall finish the conduits 300mm from the specified mounting heights to enable accurate positioning after the tile setting out has been defined.

1.48.11 Where steel, a short stub of conduit shall be inserted in the open end of the coupler to prevent the thread rusting during the period which elapses between the installation of the coupler and that of the final end of conduit to the outlet box.

1.48.12 The Contractor's attention is drawn to the need for accurate positioning of boxes in the centre panels or on the centre lines of ceiling tiles. Generally, ceiling layout drawings shall be provided by the Contract Administrator showing the setting-out lines for patterned or panelled ceilings.

1.48.13 Break joint rings or over-sized lids shall be installed for all flushed-in circular draw-in boxes, light termination points and ceiling switch points unless the accessory masks the box by 12 mm on all sides.

1.48.14 The Contractor shall be aware that the accommodation of outlet boxes in fair-faced brickwork necessitates close co-ordination between the Contractor and Contract Administrator especially in the early stages of the project and before the Contractor is normally on site.

1.48.15 The Contractor shall be responsible for passing adequate information to the Contract Administrator to ensure that correct locations and alignment of boxes, etc. are made.

1.48.16 In order to conceal conduits on fair-faced brickwork installations, use shall be made of the brickwork cavity, or alternatively the conduits shall be concealed by chasing on the rear face of the wall.

1.48.17 Where steel conduits are buried in concrete at any point they shall, before being fixed in position, be coated thoroughly on the outside with bitumastic paint which must, however, be kept clear of all screw threads.

1.48.18 Where the ceilings are fixed and the ceiling void is inaccessible after completion, the outlet boxes on the ceiling shall be supported from the structure. Back entry loop-in boxes shall be employed for this purpose.

1.48.19 Conduit boxes under floor boards shall be readily accessible for maintenance purposes. Floor traps or boards shall be securely fixed or re-fixed by brass countersunk greased wood screws with flush cup washers.

1.49 Cast in-situ and screed mounted conduits

1.49.1 In order to avoid any damage or displacement which may be caused to the conduits laid in composite or concrete floors, cast in in-situ slabs, walls, beams, etc. conduits shall be securely fixed and a competent person shall be in attendance during the pouring operation.

1.49.2 On flush installations where conduits are cast in the screed or in-situ in concrete, conduits running from ceiling or roof positions to positions on walls shall be connected by means of a solid coupling 300 mm below ceiling level.

1.49.3 Conduits shall be installed in floor screeds only when it is particularly specified and care shall be taken to ensure that runs do not foul the position of any door spring boxes, mat- wells or other services.

1.49.4 The Contractor shall be responsible for the detailed co-ordination and setting-out of services cast in-situ or within screeds.

1.49.5 The Contractor's attention is specifically drawn to the requirements detailed elsewhere in this Specification for protection, cleaning and repair of conduits cast in-situ or within screeds.

1.49.6 Where it is unavoidable, crosses may be effected between conduits within screeds. The minimum separation requirement detailed elsewhere in this Specification may be relaxed in such cases, with the approval of the Contract Administrator.

1.49.7 It shall be acceptable to run point-to-point with conduits where cast in-situ or in screed. The maximum distance between access points for wiring shall be 6m, and the total angle of all of the bends between such points shall not exceed 180º.

1.49.8 The routes of all concealed conduits shall be fully detailed on working drawings, and approved by the Contract Administrator prior to commencement. Particular care shall be taken to ensure accurate records are kept of all concealed conduit routes, and that they are correctly indicated on record drawings.

1.50 External Conduits

1.50.1 Where installed externally, conduits shall comply with the above-specified requirements for surface or concealed installations as appropriate. Additionally, they shall meet the requirements of this clause.

1.50.2 All externally-mounted conduit boxes shall be fitted with neoprene gaskets, to prevent the ingress of moisture. All earthing connection holes in the rear of such boxes shall be fitted with suitably-sized brass cheesehead setscrews.

1.50.3 External conduit boxes shall not be drilled for fixing, but shall rather be supported by means of saddles on each connecting conduit, not more than 150mm from the centre of the box.

1.50.4 All external conduit systems shall have a drain hole at their lowest point. This shall comprise a 4mm diameter hole drilled into the conduit or box, allowing any accumulated moisture to escape. The positions of all such drain holes shall be noted on construction and record drawings.

1.50.5 Connections into luminaires, socket outlets and other equipment shall generally by affected from below. Care shall be taken not to reduce the IP rating of the equipment when achieving a conduit entry. Flanged couplers with washers shall be used for all such external connections.

1.50.6 Unless specified otherwise, all external conduit installations shall comprise galvanised steel as detailed elsewhere in this Specification.

1.51 Flexible Conduits

1.51.1 Flexible conduits shall only be used to protect cables over short distances, where subject to vibration or other movement. They shall not be used in lieu of a fixed conduit installation.

1.51.2 Flexible conduits and accessories shall be IP67 rated (or better) where mounted externally, in damp conditions or in plantrooms, risers, etc. In dry indoor conditions, IP54 equipment shall be used.

1.51.3 The maximum length of any flexible conduit shall be 500 mm, unless detailed otherwise elsewhere in this Specification or on the Contract Drawings. Where necessary they shall be fixed using spacer-bar conduit saddles, as described elsewhere in this Specification.

1.51.4 All flexible conduit glands shall be tightened in line with the manufacturer's recommendations, using spanners such that the glands are undamaged. Where necessary, adapters shall be employed to convert to standard metric threads. Where connecting into equipment with plain (unthreaded) entries, hexagon locknuts shall be employed.

1.52 Installation Tools

1.52.1 Steel conduits shall be set on site to form all bends, using a bending machine, all sets being made neatly and without restriction of the bore.

1.52.2 Only free-standing purpose-made conduit benders shall be employed. They shall be complete with all accessories (including stops with curved profiles), and correctly-sized formers. Knee or knuckle formers giving reduced bending radii shall only be used with the written permission of the Contract Administrator.

1.52.3 Steel conduits shall be held in an efficient vice for threading. The Contractor shall note that no badly marked conduit or poor threads shall be accepted.

1.52.4 All conduit threads cut on site shall be produced using hand-held stocks with sharp dies and guides, and an approved solvent-free, low melting point cutting lubricant. Conduits shall be wiped free of lubricant prior to installation.

1.52.5 Conduit draw tapes shall be used to assist wiring. They shall be steel or nylon, but power assisted draw tapes shall not be used without the permission of the Contract Administrator.

1.52.6 Draw tapes shall not be inserted into conduits which already contain cables.

1.52.7 Holes in adaptable boxes, etc. for conduit access shall be cut using appropriately sized hole saws and mandrills, lubricated with an approved cutting compound. Cone cutters shall not be used to expand holes without the permission of the Contract Administrator.

1.53 Testing of Steel Conduits

1.53.1 Steel conduits shall be tested for continuity before plastering or floating of concrete (sunk installations) or cabling (surface installations) is commenced. The Contractor shall also demonstrate at this time in the presence of the Contract Administrator, at his discretion, that all parts of the conduit installation are capable of withstanding a "dead" weight of 23 kg.

1.53.2 Where required by the Contract Administrator, continuity tests shall be conducted using a high-current measuring device, producing a minimum of 30A.

1.53.3 When tested the resistance shall not exceed the readings given below. Should any reading be exceeded the Contractor shall at his own expense rectify the installation to obtain a satisfactory reading, without delay to the construction programme.

Conduit Size	Resistance
20mm	1.23×10^{-3} Ohms/metre
25mm	1.14×10^{-3} Ohms/metre
32mm	0.85×10^{-3} Ohms/metre

1.54 Trunking

1.54.1 General

1.54.2 Principal trunking routes and sizes shall be as detailed on the Contract Drawings and herein. These routes shall be augmented with such secondary trunkings as may be required, which shall be shown on the Contractor's co-ordinated working drawings.

1.54.3 All trunkings sized by the Contractor shall be selected on the basis of Appendix A of Guidance Note 1 of the IEE Regulations. Where it is agreed by the Contract Administrator to substitute multiple conduit runs for trunking, it shall be the responsibility of the Contractor to demonstrate that the cable sizes selected are still valid given the revised grouping arrangements.

1.54.4 Trunking shall be run truly horizontal or vertical except where it is desirable to follow the line of a construction feature in which case the approval of the Contract Administrator shall be obtained prior to commencement.

1.54.5 Where trunking is to be installed externally or in areas subject to washing down it shall have a rating of IP65.

1.54.6 Manufacturer's standard fittings shall be used for all bends, angles, offsets, cross-overs, etc. The practice of cutting and bending trunking to form flanges and attachments shall not be permitted.

1.54.7 Where site conditions apparently necessitate site fabrication, the specific approval of the Contract Administrator for the proposals must be given before fabrication commences and the standards of fabrication and finish shall not be less than that of standard manufacturer's items.

1.54.8 No trunking shall be installed within 150mm of any gas, hot water or steam piping and where this clearance cannot be given, insulated spacers shall be fitted. Metal trunking shall also be bonded to any adjacent metal services to ensure compliance with the IEE Regulations.

1.54.9 The standard lengths of trunking used shall not be less than 2 metres, with cable retaining straps fitted at intervals not exceeding 1 metre.

1.54.10 Trunking shall be properly aligned and securely fixed at regular intervals not exceeding 2 metres on straight runs. Where bends, angles or offsets occur, additional fixings shall be supplied at a distance not exceeding 150mm on each side of the accessory.

1.54.11 Where trunking passes through walls, floors and ceilings non-combustible, non-metallic fire barriers shall be fitted. Similar barriers shall be installed in vertical trunking run in open riser ducts, at intervals not exceeding 3 metres.

1.54.12 Connectors shall span the complete internal surface of the trunking and shall be designed such that the trunking sections mate with the butting joints.

1.54.13 Vertical trunking shall be supplied with cable support units with insulated pins at intervals not exceeding 3 metres.

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

1.54.15 Trunking within ceiling voids shall be installed lid uppermost, unless detailed otherwise on the Contract Drawings or herein. It shall be supported from below, using a preparatory system of galvanised mild steel 40 x 40mm channel and accessories.

1.54.16 Fixing and jointing screws shall pass outwards from within the trunking, with fullnuts fitted to the outside. Each screw shall be cut down flush with the face of the fullnut, filed smooth and immediately treated with a preparatory cold galvanising compound immediately after installation. Cut ends of support channel/ metalwork and steel trunking shall be similarly finished.

1.54.17 No suspension shall intrude into the internal trunking space.

1.54.18 Where two or more services that require to be segregated by the IEE Regulations or this Specification are installed in a common trunking, continuous earthed steel partitions shall be employed.

1.54.19 Connections to switchgear, distribution boards etc., shall be made using flanged bell- mouth units.

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

1.54.21 Steel Trunking and Accessories

1.54.22 Steel trunking and accessories shall be manufactured generally in accordance with BS 4678: Part 1, Class 3.

1.54.23 No steel trunking smaller than 50 x 50 mm shall be installed without the written permission of the Contract Administrator.

1.54.24 Metal thickness for body and cover material shall be not less than the values stated below:

Trunking Size (mm)	Thickness (mm)	
	Trunking	Cover
50 x 50	1.0	1.0
above 50 x 50 and up to 150 x 100	1.2	1.2
above 150 x 100 and up to 225 x 150	1.6	1.6
above 225 x 150	2.0	1.6

1.54.25 Trunking and connectors shall be galvanised finished accordance with BS EN 10143, unless specified otherwise elsewhere in this Specification or Contract Drawings.

1.54.26 Where detailed in this Specification or on the Contract Drawings, trunking and accessories shall be provided with BS 4800 Epoxy powder coated finish. All other parameters shall be as described for galvanised trunking.

1.54.27 Lengths of trunking shall be efficiently bonded to each other using bonding links in compliance with the electrical continuity conditions of BS 4678. They shall be of tinned copper construction, such that they do not cause any electrolytic corrosion.

1.54.28 Lids shall be lipped and fixed at intervals not exceeding 1 metre by means of quick release cam type fasteners manufactured from brass or steel. Steel screws and fasteners shall be protected against corrosion by a finish at least equivalent to zinc coating to BS EN ISO 1461 or BS 3382: Part 2.

1.54.29 Metal partitions in trunking shall be continuous, of minimum thickness of 1.2 mm, and the finish shall be of the same standard as the trunking. The method of fixing partitions to the trunking shall not cause long term corrosion or electrolytic action and shall be such that the partitions cannot be inadvertently displaced.

1.54.30 All steel trunking bends shall be factory made assemblies with gussets to internal corners, unless otherwise instructed by the Contract Administrator.

1.54.31 Where trunking is cut or damage has been caused during erection, the finish shall be made good. All burrs and rough edges shall be removed. Where any corrosion has occurred it shall be removed and the area immediately treated with a preparatory cold galvanising compound.

1.54.32 Any fixings used for securing the trunking shall not cause any long term corrosion or electrolytic action. Black japanned fixing screws shall not be used. Where brackets are used they shall be constructed of mild steel 40 x 40 mm channel, finished to the same standard as the trunking.

1.54.33 Where steel trunking abuts items of switchgear etc., trunking shall be slotted using a jig- saw or similar. A plate of paxolin not less than 10 mm thick shall be fitted between the trunking and equipment, with a slot with smaller dimensions than those in the trunking and equipment. Fixing setscrews shall pass from the trunking, through the paxolin to the equipment, where fullnuts shall be fitted.

1.54.34 Where detailed in this Specification or on the Contract Drawings, cables shall directly exit the trunking via bushed holes fitted with flexible edging strip, permanently fixed to avoid damage to cable sheathing.

1.55 Weatherproof Trunking and Accessories

1.55.1 Weatherproof trunking installed externally shall be heavy gauge galvanised finished with flanged overlapping lid and rubber gasket seal to IP65 rating.

1.55.2 All damaged sections of galvanised finishing shall be repaired as detailed elsewhere in this specification with all such repairs completed within four hours of installation.

1.55.3 Where external trunking connects to externally mounted equipment (such as controls panels etc.), such connections shall be undertaken from beneath. Neoprene gaskets shall be employed to prevent egress of moisture in such locations.

1.55.4 Unless detailed otherwise on the Contract Drawings or elsewhere in this specification, externally mounted trunking shall be installed lid-uppermost, supported from below. All fixing screws shall be provided with neoprene gaskets.

1.55.5 All continuous runs of external trunking exceeding 5m in length shall be provided with a 2mm diameter drain hole at the lowest point.

1.55.6 Where external trunkings pass through roofs, etc. they shall be provided with a section of fixed lid, extending 300mm above the roof surface, enabling a bitumen or similar seal to be made by others.

1.56 Cast in Situ or in Screed

1.56.1 Where shown on the Contract Drawings or detailed herein, trunking shall be cast in-situ or within floor screeds. In all instances, trunkings in such situation shall be installed in strict accordance with the manufacturer's recommendations.

1.56.2 Particular care shall be taken with regard to the prevention of ingress of concrete or other foreign matter. All lids shall be securely in place prior to pouring, and all ends shall be fitted with purpose-made temporary seals.

1.56.3 Trunkings shall be fixed at intervals to suit manufacturer's recommendations, subject to a maximum spacing between fixings of 1500mm. All fixings shall comprise external brackets, and the trunking body shall not be drilled for fixing purposes.

1.56.4 The Contractor shall be responsible for his installation during the pouring stage, and shall provide such personnel as may be necessary to liaise with other trades and ensure that the trunking system suffers no detrimental effect during this process.

1.56.5 Where metallic trunkings are employed, the end-to-end resistance of each and every section shall be measured both immediately before and after the concrete is poured. Any increase in these figures shall require that the trunking system be immediately uncovered, and the defect rectified. The figures for these tests shall be recorded on approved sheets, and shall be issued to the Contract Administrator for approval. They shall also form part of the operating and maintenance documentation handed over prior to Practical Completion.

1.57 Plastic Trunking and Accessories

1.57.1 Plastic trunking and accessories shall be high impact PVC-U extrusions to comply with BS 4678 Part 4. The trunking and accessories shall be made by a manufacturer holding the appropriate British Standard Institution licence for the conduits specified.

1.57.2 No plastic trunking smaller than 40 x 25 mm shall be installed without the written permission of the Contract Administrator.

1.57.3 Unless differently detailed in this Specification or on the Contract Drawings, trunking and accessories shall be provided with white finish.

1.57.4 Partitions in trunking shall be continuous and the material and finish shall be of the same standard as the trunking. The method of fixing partitions to the trunking shall be such that the partitions cannot be inadvertently displaced.

1.57.5 All plastic trunking bends shall be factory made assemblies with gussets to internal corners, unless otherwise instructed by the Contract Administrator.

1.57.6 Where trunking is cut or damage has been caused during erection, the damaged parts shall be replaced. All burrs and rough edges shall be removed.

1.57.7 Plastic trunking shall be fixed by means of brass round-head screws through the trunking body into the surface onto which it will be fixed and may not be permanently fixed by means of adhesive tape, which are only allowed for temporary fixings prior to permanent fixings being applied.

1.57.8 Where trunking abuts items of switchgear, etc. trunking shall be slotted using a jig-saw or similar. A plate of paxolin shall be fitted between the trunking and any metal equipment, with a slot with smaller dimensions than those in the trunking and equipment.

1.58 Cable Tray

1.58.1 General

1.58.2 The types, sizes and routes of principal cable trays shall be as shown on the Contract Drawings. Secondary routes shall be selected by the Contractor, and shall be fully co-ordinated on his working drawings. All trays shall be sized on the basis of 25% spare capacity for future cabling, as detailed elsewhere in this Specification.

1.58.3 Unless detailed otherwise in this Specification or on the Contract Drawings, all cable trays shall be Medium Return Flange mild steel with galvanised finish.

1.58.4 All cable trays employed on this project shall be selected from the ranges of a single manufacturer.

1.58.5 Except where specified or detailed otherwise on the Contract Drawings, the Contractor shall be responsible for the selection of the correct grade of cable tray to meet site conditions and the requirements of this Specification.

1.58.6 All cables trays shall have Admiralty pattern slots, unless agreed otherwise by the Contract Administrator. Any alternative slot patterns shall be subject to the approval of the Contract Administrator, prior to materials being ordered.

1.58.7 All accessories including bends (vertical and horizontal), intersections, tees, risers and reducing sections shall be purpose made by the tray manufacturer. Where site conditions apparently necessitate site fabrication the specific approval of the Contract Administrator for the proposals shall be obtained before fabrication commences, and the standards of fabrication and finish shall not be less than those of standard manufacturer's items.

1.58.8 Bends/tees shall be of the same material thickness and finish as the tray and shall be of the "gusset" type.

1.58.9 Sections of cable tray and accessories shall be jointed in accordance with the recommendations of the manufacturers or alternatively by using mushroom-head roofing bolts, nuts and washers. Where the manufacturer's recommendations preclude the use of bolted joints then the alternative methods shall be submitted for the written approval of the Contract Administrator prior to the placing of orders for any cable tray or accessory.

1.58.10 Any damage caused to accessories or finish during cable installation or otherwise prior to Practical Completion shall be made good by the Contractor to match the tray finish. All jointing screws, nuts and washers shall all be galvanised or sheradised steel, cut down flush with nut faces. They shall be filed smooth, and treated with a cold galvanising compound immediately after erection.

1.58.11 Cable trays shall be cut along a line of plain metal and not through perforations. Burrs or sharp edges shall be removed prior to the installation of tray sections or accessories.

1.58.12 Holes cut in cable tray shall be suitably bushed with grommets complying with BS 1767. Fixings and supports shall be formed from sections of proprietary 40 x 40 mm support channel and accessories. The ends of cut sections of support channel/steelwork shall be filed and painted as detailed above.

1.58.13 Cable tray shall be supported so that the designed cable load, plus an allowance of 25%, can be carried with a maximum deflection between supports of 5 mm. Fixings and supports shall be installed at regular intervals not exceeding 1200mm along straight runs, and not more than 150mm from all bends, tees, intersections and risers. Midspan joints between cable tray sections shall be avoided and they shall be positioned as close as practicable to the tray fixing or support.

1.58.14 A minimum clear space of 25mm shall remain behind all installed runs of cable trays. Cable trays shall generally be installed such that they offer direct support to cables. Where horizontal runs of cable tray cross building or structural expansion joints, then the tray shall be cut between supports installed on either side of the expansion joint. The tray sections shall then be jointed with bolts, nuts and washers installed in elongated holes permitting a lengthwise movement of plus or minus 10mm from the initial fastening position. Vertical runs of cable tray shall not be installed such that they straddle vertical expansion joints of the building structure.

1.58.15 Metallic cable tray and accessories shall be electrically and mechanically continuous throughout its length and bonded to earth. Expansion joints shall be bridged with green/yellow 4mm²PVC insulated stranded copper single core cable.

1.58.16 All cable tray runs shall be continuous from end to end. Gaps shall only be provided in exceptional circumstances and with the written permission of the Contract Administrator. Any such gaps in metallic tray shall be bridged as detailed above.

1.59 Steel Cable Tray

1.59.1 Steel cable trays shall be perforated and supplied in nominal 2.5 metre lengths manufactured from cold reduced mild steel in accordance with BS 1449 Part 1.

1.59.2 Cable tray metal thicknesses shall as a minimum meet the following dimensions: Metal Thickness (mm):

Tray Size (mm)	Medium Duty	Heavy Duty
75mm - 300mm	1.0mm	1.5m
450mm - 900mm	1.5mm	2.0mm

1.59.3 Unless otherwise detailed elsewhere in this Specification or Contract Drawings, cable tray and accessories shall be supplied with a hot dip galvanised finish to BS EN ISO 1461.

1.59.4 Any damage caused to the tray, accessories or finish prior to Practical Completion shall be made good by the Contractor. The finish shall be made good using either a zinc rich epoxy primer or equal alternative with a generous overlap on the existing sound metal coating. The jointing screws, nuts and washers shall all be galvanised or sheradised steel, brass shall not be used.

1.59.5 Alternative finishers shall only be provided where specifically detailed elsewhere in this document or on the Contract Drawings. Where called for, such finishes shall apply to all associated accessories, and shall be as follows:

- Pre-galvanised, to BS EN 10143
- Epoxy powder coated, to BS 4800
- uPVC - coated

1.59.6 All cable tray joints shall be complete with tinned copper earthtags.

1.59.7 All lengths of steel cable tray terminating at equipment shall be securely bonded to the earth terminal of that equipment. Bonds shall comprise 4mm² 6491X cable with green and yellow insulation, connected to trays by means of ring-type compression lugs and M4 brass cheesehead setscrews, fullnuts and washers.

1.59.8 Any breaks in the continuity of tray runs shall be bridged generally as described above. Internal and external rising bends shall be factory-formed, with cuts to return flanges welded so as to provide a rigid construction.

1.59.9 Reducers shall be factory made, gusset-type. Where fishplates are required they shall be perforated and finished to match the cable tray.

1.59.10 Where specified, closed or ventilated tray covers shall be provided. They shall match the construction and finish of the associated cable tray, and shall be fixed using M6 roofing nuts and bolts as previously specified. They shall be fixed to traywork using purpose- made brackets.

1.59.11 Covers to bends, tees, etc., where not available from tray manufacturer, shall be cut on site. They shall be mitred, and shall have overlapping fishplates, and shall be subject to the detailed approval of the Contract Administrator.

9.17.3 Wire Cable Tray

1.59.12 Wire cable trays shall be manufactured from zinc plated steel with silver passivated finish.

1.59.13 The jointing screws, nuts and washers used on wire cable trays shall all be of matching material and finish, brass shall not be used.

1.59.14 All wire cable tray joints shall be made with suitable fixed or adjustable couplers complete with tinned copper earth bonding links.

1.59.15 All lengths of wire cable tray terminating at equipment shall be securely bonded to the earth terminal of that equipment. Bonds shall comprise 4mm² 6491X cable with green and yellow insulation, connected to trays by means of ring-type compression lugs and M4 brass cheesehead setscrews, fullnuts and washers.

1.59.16 Any breaks in the physical and earth continuity of tray runs shall be bridged generally as described above.

1.59.17 Where specified, tray covers shall be provided. They shall match the construction and finish of the associated wire cable tray, and shall be firmly fixed to trays using purpose- made brackets.

1.60 Fused Switches

1.60.1 Fuse switches shall comply with BS EN 60947-3 'Specification for air-break switches, air- break disconnectors, air-break switch disconnectors and fuse combination units for voltages up to and including 1000V ac and 1200V dc utilisation category AC22A'. The operating mechanism shall be of the spring-loaded type, such that the speed of operation cannot be controlled by the operator. In the event of a spring failure it shall be possible to open the switch without endangering the operator. Full closing or opening of the switch shall not depend upon the operator pushing the operating handle fully home.

1.60.2 The door of each compartment shall be mechanically interlocked with the switch mechanism such that the door cannot be opened whilst the switch is closed.

1.60.3 The switch shall incorporate ON/OFF indication and have facility for locking the switch in the off position.

1.60.4 Parts which remain alive when covers are opened shall be shrouded against accidental contact with tools. Units shall be screened to permit work in safety on the load side of any circuit with adjacent circuits remaining in service.

1.60.5 Mounting arrangements of fuse switches should be such that individual complete units can be disconnected and withdrawn without interfering with adjacent units.

1.61 Isolating Switches

1.61.1 All isolators shall comply with BS EN 62271-102 'AC disconnectors (isolators) and earthing switches of rated voltage above 1KV', utilisation category AC23A, and shall be of the fault making load breaking type, read in conjunction with BS EN 60694/IEC 60694.

1.61.2 They shall be housed in separate compartments and an interlock shall be provided such that access to live parts cannot be obtained while the switch is closed, and the switch cannot be closed while live parts are exposed.

1.61.3 The manufacturer of the isolators shall be the same as the manufacturer of all other switchgear, and the colour and finish shall match that of all other switchgear.

1.61.4 The switch shall incorporate ON/OFF indication and have facility for locking the switch in the off position.

1.61.5 Mounting arrangements should be such that individual complete units can be disconnected and withdrawn without interfering with adjacent units.

1.62 Fuses

1.62.1 Fuse links shall be high breaking capacity conforming to BS 88 'Cartridge Fuses of voltage rating up to and including 1000V ac and 1500V dc' (unless otherwise specified) and of the make and ratings detailed in the schedules and drawings. Fused switches rated at 200 amps and over shall incorporate a spare fuse container, containing 3 No HRC fuses of the rating used.

1.63 Contactors

1.63.1 Contactors shall comply with British Standard EN 60947-4-1, Part I - "Contactors", when supplied separately or in combination with other gear, Category A.4. A (AC) duty, mechanical duty classes 3 and 4.

1.63.2 The contactors shall be of the alternating current "clapper" type having the main moving and auxiliary contacts mounted on a common insulated steel shaft pivoted and supported at both ends. All contacts shall be silver plated, spring loaded and main contacts shall be suitably designed for efficient arc extinction and shall incorporate arc extinction chutes.

1.63.3 Unless detailed otherwise in this Specification or on the Contract Drawings, all contactors shall have coils rated at 24v DC. The rectifiers for the coil circuits shall be incorporated on the contactor chassis, and shall be protected by fuses of suitable rating.

1.64 Electronic Surge Protection Units

1.64.1 Surge protection equipment shall be in compliance with BS 6651 Appendix C, BS EN 60099-1/IEC 60099-1 and IEEE C62.41.

1.64.2 For mains protection purposes, they shall comply with the 'High' exposure level of the appropriate location category, as detailed in tables 22-24 of BS 6651. Where used for protection of data services, they shall meet the 'High' exposure level criteria of table 25 of that document.

1.64.3 Protection units in categories B and C for mains protection shall be parallel-connected types, while category A and all data transmission types shall be in-line connected. In all cases, a 'relative' earthing system shall be used, with an independent earthing connection between the protection unit and the earth terminal of the equipment concerned. The bonding conductors shall comprise green and yellow 6491X cable, sized in accordance with IEE Regulations Table 54G.

1.64.4 The incoming and outgoing cables to protection units shall be segregated, on or in separate containment/support systems. The above specified earthing conductor shall be segregated from the outgoing wiring.

1.64.5 Where parallel connections are provided, they not exceed 250mm in length, and in all cases the length of the earth connection shall be kept to an absolute minimum. Parallel connection conductors shall be bound together with spiral wrap throughout their length.

1.64.6 All protection units shall incorporate on-board neon or LED indication of the following parameters:

- Full protection present
- Reduced protection - replacement required
- No protection - failure of unit

1.64.7 The above indication shall apply to all combinations of neutral, phase(s) and earth. Each unit shall incorporate facility for remote indication via volt-free contacts.

1.64.8 Unless detailed elsewhere in this Specification or on the Contract Drawings, all mains protection units shall be mounted within switchgear enclosures, with indication clearly visible from outside the unit. Data protection units shall be DIN-rail mounted where stand-alone, they shall be mounted through the covers of purpose-made enclosures of earthed sheet steel.

1.64.9 All protection units shall be tested using an impulse generator, with results recorded using a high-speed network analyser. Mains voltage units shall be tested live, with a coupling filter network installed between the impulse generator and the protection unit. Additionally, a back filter shall be installed preventing the impulse voltage from travelling back upstream through the electrical distribution network.

1.64.10 All test results shall be incorporated on typed sheets into the Operating and Maintenance Manuals.

1.65 Loose Switchgear

1.65.1 All individual items of loose switchgear shall comply with the specific requirements as detailed elsewhere in this Specification.

1.65.2 The layout of each arrangement of loose switchgear shall be drawn up and submitted to the Contract Administrator for approval prior to commencement of works.

1.65.3 Each item shall have its own sheet steel enclosure, and shall be independently supported either on a steel channel frame or directly by the building fabric, as noted on the Contract Drawings or elsewhere in this Specification.

1.65.4 Where equipment is abutted and connected to busbar chambers, trunking etc. a paxolin infill plate shall be provided. It shall be not less than 10mm thick, and shall have a cut- out of sufficient size to allow the necessary cable access.

1.65.5 Where large numbers of relays or contactors are to be installed together (for lighting control, etc.) they shall be fitted in a common, purpose-made sheet steel enclosure, with due attention to heat build-up.

1.65.6 All loose switchgear shall have a minimum ingress protection rating of IP41 for dry internal situations, and IP65 for external positions, and impact protection to IK10 in all cases.

1.65.7 Each item of equipment forming part of a loose switchgear panel shall be bonded together, using a green and yellow-sheathed 6491X cable sized in accordance with Table 54G of the IEE Regulations (based on the size of the incoming supply cable). The bonding shall be routed internally, and shall be connected to each earth terminal using a ring-type compression lug. Any mounting frame shall also be bonded in this fashion.

1.66 Insulating Mats

1.66.1 The Contractor shall supply and install heavy-duty rubber insulating mats for the full length of the main switchboard, each local switch panel, and each mechanical services control panel.

1.66.2 All mats shall be of a grade and thickness to suit the highest voltage present within the associated equipment, subject to a minimum of 500V.

1.66.3 The rubber mats shall be a minimum of one metre wide.

1.67 Distribution Boards

1.67.1 Distribution boards shall comply with BS 5486-12.

1.67.2 Each distribution board shall have a hinged access door and shall have an IP41/IK10 rated enclosure.

1.67.3 Each distribution board shall have an insulated protective shield to prevent accidental contact with live parts, and each neutral and earth bus-bar shall have an outgoing terminal for each circuit breaker.

1.67.4 Triple pole and neutral boards shall be suitable for mounting single, double and triple pole MCBs in any combination.

1.67.5 Labels showing board references shall be supplied and screwed to the front of each distribution board, as detailed elsewhere in this Specification. Where distribution boards incorporate residual current devices, an external label shall be provided as detailed under IEE Regulation No 514-12-02.

1.67.6 Unless a distribution board has an adjacent means of isolation with On/Off indication, each distribution board shall include an indicating device to show whether the incoming supply is ON or OFF and an integral isolating switch.

1.67.7 The number of ways detailed for each distribution board on the Schedules or Contract Drawings specify the number of MCBs or MCBs with integral RCD, and spare ways required for the future provision of a combination of the same, and not the number of modules.

1.67.8 The Contractor shall select the number of modules required for each distribution board to suit the total number of ways specified based on the arrangements of the particular manufacturer.

1.67.9 All distribution boards shall be fitted with "key" lock facility. Keys shall be common to all distribution boards supplied under this contract.

1.68 Miniature Circuit Breakers

1.68.1 All miniature circuit breakers (MCBs) shall be constructed to the BS EN 60898, 'Miniature air-break circuit breakers for AC Circuits', and IEC 898.

1.68.2 All breakers shall be of the thermal/magnetic type with silver tungsten contacts and shall be de-rated to suit the nature of enclosure and/or type of load.

1.68.3 Unless otherwise specified the minimum AC rated short circuit capacity of MCBs shall be equal to or greater than the prospective short circuit current at that point of the installation in accordance with current regulations, subject to a minimum rating of 9kA.

1.68.4 All MCBs shall be Type B Standard, unless detailed otherwise elsewhere in this Specification or on the Contract Drawings.

1.68.5 MCBs, whether single or multi-pole (where installed in TP and N Distribution Boards) shall be so constructed that they are readily connected to all phases without modification. They shall also be readily removable for replacement without disturbance to adjacent circuits.

1.68.6 Miniature circuit breakers protecting socket outlet circuits or external lighting shall be provided with 30mA RCDs to BS 4293/BS EN 61008-1/BS IEC 1008-2-2 unless otherwise detailed on the Contract Drawings or indicated in the schedules.

1.68.7 Miniature circuit breakers shall be identified by their respective phase colours and a number corresponding to the circuit list affixed to the inside of the door cover.

1.69 Lighting

1.69.1 The Contractor shall provide a complete set of lighting systems as shown on the Contract Drawings.

1.69.2 The systems shall comprise individually mounted fluorescent luminaires, downlighters, emergency luminaires or emergency packs connected to normal luminaires to provide emergency lighting in the positions as indicated on the Contract Drawings.

1.69.3 The luminaires shall be wired and controlled as indicated on the Contract Drawings and herein, and shall without exception be complete with lamps of the type and colour temperature specified.

1.69.4 The final positions of all luminaires, switches, associated equipment and conduit routes shall be verified with the Contract Administrator by the Contractor, prior to commencement of the installation.

1.69.5 All bodies of luminaires within areas of suspended ceilings shall be handed to the Contractor for the cutting of the apertures and the installation to the ceiling. The Contractor shall allow for the final connection, installing the lamps and as a separate exercise the installation of the louvres and other items susceptible to dust immediately prior to handover.

1.70 Switches and Switching

1.70.1 Flush and/or surface mounted switches conforming to this Specification shall be provided as detailed on the Contract Drawings.

1.70.2 Lighting switches shall comply with BS 3676/BS EN 60669-1 'Switches for domestic and similar purposes (for fixed or portable mounting)' and shall be suitable for use on inductive or resistive loads. They shall be of the AC only rocker operated "Grid Switch" type rated at 20A.

1.70.3 Where several switches on one phase are shown mounted adjacent one to another they shall be grouped in a single enclosure (multi-gang box) and share a common switch plate.

1.70.4 Where more than one phase supplies one multi-gang switch unit a 415V warning label shall be provided in accordance with the IEE Regulations for the Electrical Equipment of Buildings, current edition.

1.70.5 Where switches are shown mounted adjacent to each other, but are fed from different distribution boards, then each switch shall be mounted in a separate enclosure.

1.70.6 Where possible the arrangement of switches in multi-gang boxes shall be similar in plan to the lighting points that they control. Switches not so arranged shall be labelled in a suitable manner so as to indicate the circuits controlled.

1.70.7 Recessed lighting switches connected to conduits shall be mounted in switch boxes of minimum depth 37mm fitted with adjustable grids to allow for variations in the thickness of plaster.

1.70.8 The face-plates of recessed lighting switches shall be fixed square and flush with the wall. Fixing rings shall not be the only means of securing the face plates. Surface mounted lighting switches shall be installed only in areas where surface mounted conduits are specified and shall be fitted to either malleable cast iron or pressed steel boxes of minimum depth 37 mm. The cover plates shall give protection to the rockers.

1.70.9 Unless indicated otherwise on the Contract Drawings switch-plates shall be as follows:

- Flush mounted switches to principal and circulation areas shall have slim-line overlapping plates finished polished stainless steel.
- Flush mounted switches to secondary and ancillary areas (such as stores, etc.) shall have overlapping plastic plates finished white.
- Surface mounted switches shall be of the cast metal clad type with stainless steel cover plates with a powder lacquer finish.

1.70.10 In damp or outside positions switches shall be single pole, and operated by external means. The switch enclosure shall be either weatherproof of galvanised metal construction and designed to protection level of IP65, or if plastic splash proof to IP54, and impact-protected to IK10 requirements.

1.70.11 Cord operated switches shall be fixed to circular BS boxes using break-joint rings. The switches shall be white or ivory coloured and 20A AC rated, one or two way as shown. They shall be fitted with silent interiors and operating cord of minimum length 1.5 metres.

1.71 Lamps

1.71.1 Unless otherwise indicated in the Schedules, all lamps shall be LED with a colour temperature of 4000K and a life expectancy of at least 10000 hours.

1.72 Lamp holders

1.72.1 Lamp holders shall be suitable for specified lamps and shall be constructed in compliance with the relevant British Standard.

1.72.2 Where lamp holders are fixed direct to metallic conduit systems they shall be brass, other than in a bathroom or toilet areas when they shall be insulated. Insulated lamp holders shall be complete with Home Office pattern skirts. Batten lamp holders shall be suitable for direct mounting on circular conduit boxes.

1.72.3 Lamp holders for use with tubular fluorescent lamps shall be bi-pin complying with BS EN 5042 Part 4/BS EN 60400, BS 5101 Part 1 and BS 5101 Part 3 'Bi-pin lamp caps and lamp holders for tubular fluorescent lamps for use in circuits, the declared voltage of which does not exceed 250 volts'.

1.73 Emergency Lighting

1.73.1 General

1.73.2 Emergency lighting shall be provided in compliance with the requirements for emergency and escape lighting under BS 5266, BS EN 1838 and CIBSE TM12.

1.73.3 Unless noted otherwise in this Specification or the Contract Drawings, all emergency systems shall be rated for 3-hour maintained operation. A test record card shall be provided for each individual luminaire. They shall be completed by the Contractor for the initial test prior to handover, and then placed within a ring binder and issued as part of the Operating and Maintenance documentation.

1.73.4 In order to facilitate easier future testing, each card shall be numbered, to coincide with reference numbers added to record drawings against each emergency luminaire.

1.74 Self-contained Luminaires

1.74.1 Self-contained emergency luminaires shall be provided as detailed in this Specification and the Contract Drawings.

1.74.2 All luminaires shall be correctly rated for their local environments in terms of heat dissipation and IP-rating. They shall have integral batteries comprising sealed single nickel cadmium cells, complying with BS EN 61951-1. They shall also incorporate integral charger units, specifically designed to suit the batteries and providing full compliance with BS 5266.

1.74.3 Where shown on the Contract Drawings or specified herein, emergency luminaires shall be fitted with self-adhesive legends. All such legends shall feature the white-on-green 'running man' symbol, as required by the European Signs Directive and ISBN 0 7176 0870 0.

1.74.4 All self-contained emergency lighting luminaires shall be certified to ICEL 1001.2. Lamps shall be of the low energy fluorescent type, coloured 3500K.

1.74.5 Where twin-beam high output emergency luminaires are specified they shall be non- maintained models, installed not less than 20°above the line-of-sight as detailed in BS 5266. The limitations on disability glare described in CIBSE TM12 shall also be adhered to.

1.75 Inverter Units and Conversions

1.75.1 Where detailed in this Specification or shown on the Contract Drawings, emergency lighting shall be provided by means of inverter and battery units connected to standard luminaires.

1.75.2 All such conversions shall provide M3 operation, and shall be undertaken at works. In multi-lamp luminaires, only one lamp shall operate under emergency conditions.

1.75.3 Wherever possible, the inverter and battery pack shall be integral to the luminaire, which shall be modified as required to suit the weight and heat output of the additional equipment. Where this is not possible, batteries and invertors shall be enclosed in sheet steel ventilated boxes, fixed to the structure not more than 1.5m from the luminaire.

1.75.4 Batteries shall comprise sets of sealed nickel cadmium cells, complying with BS EN 61951-1. Invertors shall be specifically designed to suit the batteries, and shall provide full compliance with BS 5266.

1.75.5 All converted luminaires shall incorporate integral red LED indicators, which shall be illuminated when the charging supply is healthy.

1.75.6 LEDs shall be mounted in bezels of downlighters, in louvres of fluorescent luminaires, or in such other positions as may be directed by the Contract Administrator. All LEDs shall be clearly visible from the ground with all lamps illuminated.

1.75.7 Inverter packs for emergency conversion of downlighters shall be sized so as to pass through the luminaire ceiling aperture.

1.75.8 Where discharge sources form the general purpose lighting installation, emergency conversions shall be of the sustained type using a tungsten halogen capsule lamp. In such cases a timed circuit shall be provided such that the secondary lamp is illuminated during the initial and re-strike delay period as well as in power failure conditions.

1.75.9 All emergency-converted luminaires shall meet the requirements of BS 5266, including the diffuser material 'hot-wire' test. A statement to this effect shall be provided by the Contractor prior to placement of orders.

1.75.10 All luminaires covered for emergency use shall be fitted with monitoring modules to work in conjunction with the above specified automatic testing systems.

1.76 Installation of Self-contained and Converted Luminaires

1.76.1 All self-contained and/or converted luminaires shall be connected to the same final sub- circuit as the remainder of the luminaires in the area.

1.76.2 A local test/maintenance key switch shall be provided, either at the distribution board or adjacent to the luminaire as shown on the Contract Drawings.

1.76.3 The key switch shall interrupt both the supply to the emergency luminaire(s), and that to all of the standard luminaires in the room or area (as appropriate). Key switches shall be installed such that up is normal, and down is test.

1.76.4 Where mounted adjacent to luminaires key switches shall be on a common plate with local lighting control switches. They shall be 20A AC rated grid types, with secret key operation, common throughout the project.

1.76.5 One key for each switch provided, up to a maximum of 20 No, shall be issued to the Contract Administrator at the completion of the works.

1.76.6 Where normal lighting is connected via plug-in ceiling roses, emergency luminaires shall also use this method of connection. For maintained luminaires ceiling roses shall be four- pin, otherwise matching local units. Final connections shall be made using 4-core 1mm² LSF flex type 3184-LSF, with conductors used as follows:

- Brown - unswitched phase
- Blue - neutral
- Black - switched phase
- Green and Yellow - earth

1.76.7 Where inverter/battery units are not integral to luminaires, they shall be fixed directly to the building structure adjacent. All cabling shall be routed via the battery/battery units.

1.76.8 The Contractor's attention is specifically drawn to the requirements for segregation of different wiring categories, as detailed elsewhere in this Specification.

1.77 Labelling of Emergency Lighting Test Switches

1.77.1 Multi-gang switches of three or more gangs, the groups of luminaires controlled by which are not easily identifiable, shall have their face plates engraved to identify their function.

1.77.2 Key switches controlling emergency lighting which share a switch plate with local lighting switches shall have "EL" engraved above them, and "TEST" beneath.

1.77.3 The exact legend for all other switches shall be agreed with the Contract Administrator. All engraving shall be 6 mm black lettering, excepting that associated with emergency lighting which shall be in red lettering.

1.77.4 All emergency luminaires shall be labelled in accordance with BS 5266 Part 1 requirements.

1.77.5 Conduits and wiring shall be identified as detailed elsewhere in this Specification.

1.78 Power Accessories

1.78.1 General

1.78.2 All small power accessories shall comply with the requirements of the following clauses, unless noted otherwise elsewhere in this specification or on the Contract Drawings.

1.78.3 All wiring and circuitry arrangements shall be detailed elsewhere in this Specification. Unless noted otherwise elsewhere in this Specification or on the Contract Drawings, accessories shall be as follows:

- Flush mounted outlets to principle and circulation areas - slimline stainless steel overlapping face-plates, with polished finish.
- Flush mounted outlets to secondary areas (such as stores, etc.) – white plastic.
- Plantrooms, risers, ceiling voids, etc. – surface mounted, with powder lacquer finished aluminium plates.

1.79 Socket Outlets

1.79.1 Surface and flush mounted switched socket outlets shall have shuttered sockets and AC only switches.

1.79.2 13 Amp socket outlets and plugs shall comply with BS 1363 '13A plugs, switches and unswitched socket outlets and boxes'. The plugs shall contain the correct rated cartridge fuse links complying with BS 1362 'General Purpose Fuse Links for domestic and similar purposes (primarily for use in plugs)' to protect the apparatus or appliance connected to the outlet. Where not specifically detailed, fuse links shall be rated in accordance with Table 55A in the IEE Regulations.

1.79.3 Where denoted “NS” on the drawings, socket outlets shall have non-standard earth pins, rotated through 90°.

1.80 13 Amp Fused Connection Units (Switched Spur Units)

1.80.1 Fused connection units for use in ring final sub-circuits shall be double pole switched. Cables to apparatus connected to a fuse connection unit shall be protected by a cartridge fuse link of the correct rating. Cartridge fuse links shall comply with BS 1362 'General purpose fuse links for domestic or similar purposes (primarily for use in plugs)'.

1.81 Isolating Switches

1.81.1 Isolating switches shall be as detailed elsewhere in this Specification and as shown on the Contract Drawings. They shall comply with BS 3676: Part 1/BS EN 60669-1 and BS EN 60947-3 as appropriate, and shall be AC22 rated.

1.81.2 Where flush mounted units are specified with cord outlets, they shall be of smooth bore with an internal cord grip. For surface mounted units, cord outlets shall comprise brass compression glands and locknuts within the bottom face of the back box, as detailed elsewhere in this Specification.

1.81.3 The Contractor shall note that isolators and switch-disconnectors used for connection of mechanical services plant shall be as detailed elsewhere in this Specification.

1.82 Cable Outlet Units

1.82.1 Outlet plates for cables or flexible cords shall be similar to switch plates with 60.3mm fixing centres and complete with not less than two fixing screws. Terminals shall be provided to accommodate 2 x 2.5mm²incoming cables and a 1.5mm² outgoing flexible cord. The unit shall be unfused and shall incorporate an outgoing cable clamp or cord grip. The cover plate shall have a smooth aperture for the flexible cord exit.

1.83 Double Pole Switches

1.83.1 Flush and/or surface mounted double pole switches conforming to BS 3676: Part 1/ BS EN 60669-1 shall be provided as detailed on the Contract Drawings.

1.83.2 Where flush mounted units are specified with cord outlets, they shall be of smooth bore with an internal cord grip. For surface mounted units, cord outlets shall comprise brass compression glands and locknuts within the bottom face of the back box, as detailed elsewhere in this Specification.

1.84 Extra Low Voltage Socket Outlets (Plantrooms)

1.84.1 In the positions shown on the Contract Drawings, the Contractor shall supply and install 110V extra low voltage transformer/sockets as follows.

1.84.2 Each unit shall have an output capacity of 600VA with primary voltage of 240 volts, 50 Hertz and a secondary of 110 volts between conductors (55V to earth). The output voltage shall be adjustable by means of internal connections.

1.84.3 Each unit shall have a double wound transformer with the primary and secondary windings separated by an earthed screen. The transformer shall be protected by 2 No fuses on the outgoing secondary connections.

1.84.4 Each unit shall be fitted with a double pole switch to control the incoming supply.

1.84.5 Each unit shall be fitted with one socket outlet to BS EN 60309-2/IEC 60309-2 and shall be complete with one matching plug top. They shall be 110-130V 16A rated, 3 pin, coloured yellow, with the earth connection at the 4 o'clock position.

1.84.6 The low voltage unit shall be contained in an enclosure suitable for conduit entry. This enclosure shall be of rust proof cast alloy construction and finished with enamel paint, with protection ratings of IP54 and IK10.

1.84.7 Unless indicated otherwise on the drawings the Contractor shall supply and install 1 No. hand lamp and lead for each ELV socket outlet. They shall comprise of a 110v ES handlamp with cage, 60W GLS lamp, and 15m of 3 core circular laid rubber sheathed 1.5mm² flexible cable type 3183 TQ.

1.84.8 The hand lamp, flexible cable and the low voltage unit plug top shall be made up into a complete assembly by the Contractor and attached to wall fixed brackets purpose made to hold the combined unit.

1.85 Labelling Of Power Accessories

1.85.1 Each isolating switch faceplate shall be engraved giving details of the rating and circuit/equipment identification. The characters shall be 6 mm high, coloured black, generally as detailed elsewhere in this Specification.

1.85.2 Double pole switches and spur units installed above the work tops in kitchens and similar locations shall be engraved with the name of the equipment or appliance which they feed in 6 mm lettering coloured black.

1.85.3 Cabling and conduits shall be identified as detailed elsewhere in this Specification.

1.86 Electrical Work Associated with Mechanical Services

1.86.1 General

1.86.2 The Contractor shall supply, deliver to site, unload, store, install, test and commission all of the power and controls wiring required for the operation of the mechanical services installation. All support and containment shall also be provided.

1.86.3 The Contractor shall make due allowance for all liaison and co-ordination as necessary to ensure a complete and fully operational installation.

1.86.4 Segregation of services shall be as detailed elsewhere in this Specification. The Contractor's attention is specifically drawn to the standards required by this Specification and the Contract Drawings. It shall be his responsibility to ensure that these standards are met in all respects by all persons and companies working on their behalf and shall inform the Contract Administrator of any works by other Contractors that fail to meet the standards set.

1.86.5 The types, standards and manufacturers of cabling and containment/support systems, together with installation methods, identification and testing, shall all comply with the detailed requirements set out elsewhere in this Specification.

1.87 Power

1.87.1 Unless detailed elsewhere in this Specification or on the Contract Drawings, all mechanical services power wiring shall comprise XLPE/SWA/PVC/LSF cables on galvanised MRF tray. Cable glands shall be BW-type internally, and CW externally or in damp/plantroom locations.

1.87.2 Local isolators shall be provided for all items of current-consuming equipment. They shall comprise rotary assemblies within cast alloy enclosures, protected to IP65 and IK10 levels. They shall incorporate the numbers of main and auxiliary contacts as shown, including late or early operation where specified. They shall comply with BS EN 60947-3, VDE 0660 and IEC 408, and shall be AC23A rated on-load devices. They shall be padlockable in the off position.

1.87.3 The ratings given in this Specification or Contract Drawings for current handling shall be taken as thermal values.

1.87.4 All isolators shall be mounted in accessible positions, between 1000 and 2000mm AFFL and not more than 2000mm from the equipment controlled, to the approval of the Contract Administrator. Where no suitable surface exists to facilitate installation, a rigid frame shall be provided, constructed from a preparatory galvanised steel channel system as detailed elsewhere in this Specification.

1.87.5 Where star-delta motors are used, local isolators shall be 6-pole with an auxiliary contact that shall break the control circuit, precluding the restarting of the motor in the delta phase.

1.87.6 Final connections between isolators and plant shall comprise flexible steel conduit and single core cable, as detailed elsewhere in this Specification.

1.87.7 Motors and other equipment with stud-type terminals shall be connected using ring-type compression lugs of the smallest hole size admitted by the stud.

1.87.8 All cables shall be fitted with external labels at termination points, as detailed elsewhere in this Specification. All conductors shall be fitted with ferrule-type core numbers.

1.87.9 All numbering systems shall be subject to agreement with the Contract Administrator.

1.87.10 The materials and installation standards required for support/containment systems, cables, glands, terminations, etc. shall be in strict accordance with the specific requirements as detailed elsewhere in this Specification.

1.88 Controls Wiring

1.88.1 Unless detailed elsewhere in this Specification or on the contract drawings, all mechanical services controls wiring shall comprise a 2 core screened cable (to controls specialists specification) complete with a LSF sheath.

1.88.2 They shall be installed on dedicated ELV cable trays as indicated on the drawings.

1.88.3 Final connections within the control panel and at the appliance end will be carried out by the controls specialist with the exception of the fan coil unit connections which will be carried out by the electrical contractor.

1.89 Test Requirements

1.89.1 Tests shall be made and recorded on the electrical installation earthing system in accordance with IEE Wiring Regulations.

1.89.2 Tests shall be made both during and upon completion of the works. In order that tests may be witnessed, the Contract Administrator shall be given seven day's notice prior to testing at completion of the works.

1.89.3 The Contractor shall include for re-testing the earthing system provided under this Contract thirty days prior to the end of the Defects Liability Period. The Contractor shall give seven days written notice prior to visiting the site to make these tests.

1.90 Tests Prior to Practical Completion

1.90.1 Each and every final sub-circuit shall be tested for phase earth loop impedance as required by the IEE Regulations (Guidance Note 3) and as specified herein.

1.90.2 The resistance of each MEBC shall be tested from end to end, and its value recorded.

1.90.3 The resistance of each section of exposed metalwork crossbonded by SEBCs or additional bonding to the building main earth shall be tested and recorded.

1.90.4 Re-tests shall be carried out as aforementioned on the following basis:

- All socket outlets installed under this Contract shall be tested for phase earth loop impedance.
- Two and a half percent of all lighting points installed under this Contract (with a minimum of five), shall be tested for phase earth loop impedance.
- Should any one point not comply with the test requirements then a further two and a half percent shall be tested, when the failure of any further one point shall require the retesting of all lighting points.
- All miscellaneous plant, machinery and equipment supplied and installed under this Contract shall be tested for earth fault loop impedance.

1.90.5 Any defects discovered during these tests shall be immediately corrected at the expense of the Contractor.

1.90.6 Circuit Protective Conductor (CPC) arrangements for individual mains, submains and final sub-circuits shall be as defined elsewhere within this Specification.

1.91 Testing and Commissioning

1.91.1 General

1.91.2 The Contractor shall carry out testing and commissioning of the installation in accordance with the details of this Specification, and the IEE Regulations for the Electrical Equipment of Buildings.

1.91.3 It shall be the Contractor's responsibility to put the installation to work, and to demonstrate the correct operation of all parts thereof in accordance with the Contract Drawings and this Specification.

1.91.4 In addition, the Contractor shall carry out, to the satisfaction of the Contract Administrator, the testing and inspection procedures specified in the current edition of the Institution of Electrical Engineers Regulations, and all other tests required by this Specification.

1.91.5 On satisfactory completion of the Commissioning Procedures the Contractor shall issue test certificates as prescribed in the IEE Regulations, British Standards and herein.

1.91.6 Where required by the Contract Administrator, the Contractor shall, without cost or delay to the Contract, employ an independent external specialist company to undertake the testing specified herein.

1.91.7 The testing of specialist systems such as lighting controls, fire alarms etc. shall be undertaken by the system manufacturers under the direction of the Contractor.

1.91.8 Only when a system is fully complete, tested and commissioned shall it be offered for witnessing by the Contract Administrator. No system shall be deemed complete and acceptable without the approval of the Contract Administrator. Should a system be offered as complete and be rejected by the Contract Administrator more than twice, then the Contractor shall reimburse the Contract Administrator and all other parties involved for their costs incurred by subsequent witnessing.

1.91.9 The Contractor shall ensure that all testing and demonstration of systems and equipment is undertaken by suitably qualified and experienced personnel. Should the Contract Administrator require additional or replacement personnel they shall be provided immediately, and without delay or cost to the Contract.

1.91.10 It shall be the Contractors responsibility to provide all test instruments, dummy loads etc. required for testing and commissioning. All such instruments shall remain the property of the Contractor.

1.92 Testing by Manufacturers

1.92.1 All plant and equipment, cables and other items supplied under this Contract shall be tested in accordance with the relevant British Standard Specifications and as detailed elsewhere in this Specification.

1.92.2 The Contractor shall be responsible for supplying to the Contract Administrator on request Test Certificates from approved testing authorities, (e.g. the Association of Short- Circuit Testing Authorities) for all equipment manufactured off site.

1.93 Testing on Site during Construction

1.93.1 Tests shall be carried out as and when required by the Contract Administrator for insulation resistance, phase earth loop impedance, continuity of conduits and earth connections, together with the ability to withdraw and reinstall cables from any conduit.

1.93.2 The Contractor shall provide all instruments and personnel necessary for carrying out such tests, without cost or delay to the Contract.

1.94 Tests on Completion of the Works

1.94.1 Upon completion of the installation, the Contractor shall carry out tests as detailed elsewhere in this Specification.

1.94.2 The results of these tests shall be entered on approved Test Record Sheets and three signed and certified copies shall be handed to the Contract Administrator for approval prior to the finalisation of the installation.

1.95 Low Voltage Switchgear

1.95.1 After the final installation of all the low voltage switchgear, main switchboards and distribution cubicles, the Contractor shall carry out site checks as detailed elsewhere in this Specification.

1.95.2 The Contractor's attention is drawn to the necessity to short circuit all instrument and current transformer connections by linking-out at the terminals, to open circuit all instruments and voltage coils by removing the potential fuses, and disconnection of the current transformer earth connections during these tests.

1.95.3 The Contractor shall ensure that on completion of these tests, all temporary linking- out is removed and that the current transformer earth connections and potential fuses are replaced.

1.95.4 The results of these tests shall be tabulated and handed to the Contract Administrator for approval.

1.96 Mains and Submains

1.96.1 The Contractor shall demonstrate that the equipment installed is rated in excess of the short circuit current measured at each distribution board, switchboard and control panel.

1.96.2 Phase-earth loop impedance tests shall also be undertaken to demonstrate that the correct disconnection times shall be achieved in line with the IEE Regulations at all points in the distribution network.

1.96.3 The correct settings of all trip parameters on ACBs, MCCBs, IDMT relays, etc. shall be demonstrated. Where devices have facility for remote tripping/indication, these facilities shall also be demonstrated. The manual operation of all ACBs and MCCBs shall be checked, together with all electrical and mechanical interlocking systems. Where devices have facility for the testing of automatic operation by means of current or signal injection, these tests shall be executed.

1.96.4 All fused switches and switch fuses shall be operated, and opened for inspection.

1.96.5 All automatic changeover systems and associated indication shall be demonstrated, both in manual and automatic mode.

1.96.6 The results of all of the foregoing shall be tabulated on typed, signed and witnessed forms, and issued to the Contract Administrator in triplicate for comment.

1.97 Final Sub-Circuits

1.97.1 Each and every final sub-circuit shall be tested in compliance with Guidance Note 3 of the IEE Regulations. All parameters shall be measured, it shall not be acceptable to calculate any of the required test results.

1.97.2 The following tests shall, as a minimum, be undertaken:

- Continuity of protective conductors and supplementary bonding
- Continuity of ring final sub-circuit conductors
- Insulation resistance
- Polarity
- Phase-earth loop impedance
- RCD operation

1.97.3 The procedures laid down in the above mentioned guidance note shall be strictly adhered to.

1.97.4 The test results for each and every final sub-circuit shall be recorded on a sheet based on Form WR5 from the supplement to the Guidance Note. Should the Contractor wish to use their own form for recording test results he shall issue a draft copy of same to the Contract Administrator for approval 14 days prior to commencement of testing.

1.97.5 All completed test sheets shall be typed and signed, and shall be issued to the Contract Administrator for approval.

1.98 Lighting and Control Systems

1.98.1 The system specialist shall demonstrate the correct operation of the system to the approval of the Contract Administrator. The tests shall take the form of a complete demonstration of all of the systems control functions, and it shall be noted that this may require the building to be empty of other personnel.

1.98.2 Illumination distribution and levels shall be measured during the hours of darkness, and spot lux figures added to a set of the Contractors lighting record drawings. These drawings shall be signed by the test engineer, and issued to the Contract Administrator for approval.

1.98.3 The lighting control system shall be fully tested and demonstrated to the satisfaction of the Contract Administrator. The system shall then be demonstrated to the Client's Representative, who shall be instructed in its maintenance and modifications. The Sub- Contractor shall ensure that the system specialist provides a suitably qualified and experienced engineer to carry out this task, which shall take one full day to complete.

1.99 Emergency Lighting

1.99.1 The operation of the emergency lighting system shall be fully demonstrated to the approval of the Contract Administrator. This shall include all automatic and manual testing facilities.

1.99.2 The testing of the luminaires shall comprise the isolation of the mains supply (and any generator backup) for a period of three hours during the hours of darkness, and the recording of lighting levels at the end of the three hour period. This test shall then be repeated twenty-four hours later to confirm correct recharge of batteries. Spot lux figures from the tests shall be added to a set of the Contractors lighting record drawings, the drawings signed by the test engineer and issued to the Contract Administrator for approval.

1.99.3 In addition to the foregoing, the Contractor shall employ the emergency lighting test system manufacturer to fully test, commission and demonstrate the operation of his equipment to the approval of the Contract Administrator.

1.99.4 The tests shall demonstrate full compliance with the requirements of BS 5561. Test record cards shall be provided as detailed elsewhere in this Specification.

1.100 Mechanical Services

1.100.1 The Contractor shall provide such attendances as may be required during the commissioning of the mechanical services installation. Power circuits to items of mechanical plant shall be fully tested, and the results recorded as detailed above for final sub-circuits.

1.101 Demonstration to Clients Representative

1.101.1 The Contractor shall fully demonstrate all systems to the Clients Representative, and instruct them in their correct use and maintenance, to the approval of the Contract Administrator.

1.101.2 Representatives from all relevant specialist contractors shall undertake these demonstrations, which shall be thorough and detailed. They shall be undertaken prior to Practical Completion, and all parties shall have their Operating and Maintenance Manuals and Record Drawings available for handover on the demonstration date.

1.102 Completion Certification

1.102.1 Practical Completion shall not be granted without the provision of signed copies of the following certification:

- IEE Completion Certificate, with all associated test and inspection record sheets appended, to BS 7671.
- Fire Alarm Installation Certificate to BS 5839.
- Fire Alarm Commissioning Certificate to BS 5839.
- Emergency Lighting Completion Certificate, to BS 5266.

All of the foregoing shall be duly signed and witnessed, shall have all supporting information appended, and shall be bound up within the operating and maintenance manuals.