Specification 034

Electrical Installations

DEFENCE ESTATES
MINISTRY OF DEFENCE

Edition 1 - 2004

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Updated to include new references, current technology, materials and working practices.

Prepared by Defence Estates

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Foreword

1. This Specification is one of a series prepared by Defence Estates (DE) an agency of the Ministry of Defence (MOD) primarily for use in its contracts for mechanical and electrical engineering works. The Specification covers electrical installations for buildings other than dwellings. It is a revision of the former Property Sevices Agency (PSA) Standard Specification (M&E) No.1, dated 1985.

2. When this Specification is used in connection with a defence contract then it is to be read in conjunction with such further documents setting out contractual requirements particular to the contract. Where the words "as indicated", "where indicated" or "unless otherwise indicated" are included in the text, it is the designer/specifiers responsibility to ensure that the information referred to is included in the documentation package. (See clause 1.3.3).

3. Whilst this Specification was written by DE for use on MOD contracts, it is acknowledged that it could be usefully applied to other contracts. DE commends its use to other Government Departments. It may, therefore, be used outside the MOD Estate. However, no warranty is given as to the accuracy of this Specification or its fitness for any purpose.

4. This update includes modifications taking account of the 16th Edition of the Wiring Regulations, now British Standard (BS) 7671:2001 Amendment No. 1, 2002 (AMD 13628) and the IEE Guidance Notes issued alongside. The opportunity has been taken to update various references to other standards. It is recognised that electrical engineering standards are rapidly changing, with many BS EN series standards replacing older BS standards. Standards current at the time of contract should be assumed to be appropriate. Other updates have taken account of new materials and equipment coming into use since the last issue, and minor corrections have been made. (A major review of the scope and content has not been attempted at this time.)

5. It should be noted that this document now excludes fire alarm and detection systems and Aviation Ground Lighting installations.

6. Compliance with the contents of this document will not in itself confer immunity from legal obligations.

7. These specifications have been devised for the use of the Crown and its contractors in the execution of contracts for the Crown. The Crown hereby excludes all liability (other than liability for death or personal injury) whatsoever and however arising (including, but without limitation, negligence on the part of the Crown, its servants or agents) for any loss or damage however caused where the Standard is used for any other purpose.

8. Compliance with a DE functional standard does not of itself confer immunity from legal obligations.

Abbreviations

The following abbreviations are used in this specification:

ac	alternating current
BSRIA	Building Services Research and Information Association
BS	British Standard
BS EN	British Standard Euro Norm
CNE	Combined Neutral and Earth
COSHH	Control of Substances Hazardous to Health
CPC	Circuit Protective Conductor
dc	direct current
DE	Defence Estates
ELV	Extra low voltage
EPR	Ethylene propylene rubber
ESI	Electricity Supply Industry
GLS	General lighting service
GRP	Glass Reinforced Plastic
HOFR	Heat and oil resistant and flame retardant
HV	High Voltage
ICEL	Industry Committee for Emergency Lighting
IDMT	Inverse Definite Minimum Time
IEE	Institution of Electrical Engineers
IP	Ingress Protection as defined in BS EN 60529
LDU	Link disconnecting unit
LSF	Low smoke and fume
LV	Low Voltage
MCB	Miniature circuit-breaker
MOD	Ministry of Defence
PVC	Polyvinyl chloride
RCCB	Residual current operated circuit breaker without integrated overcurrent protection
RCBO	Residual current operated circuit breaker with integrated overcurrent protection
XLPE	Cross-linked polyethylene

Section One - General Requirements

1.1 EXTENT OF WORK

1.1.1 This Specification states the requirements for the supplying, assembling, fixing in position, connecting, inspecting, testing and leaving in working order, new, modified or additional electrical installations.

1.1.2 The work shall comprise the whole of the labour and, unless otherwise indicated, all the materials necessary to form a complete installation, including such tests, adjustments and commissioning as are prescribed in subsequent clauses and as may otherwise be required to give an effective working installation to the satisfaction of the Project Manager.

1.1.3 The words "complete installation" in clauses 1.1.2 and 1.5.1 shall mean not only the items of electrical equipment conveyed by this Specification, but all the incidental sundry components necessary for the complete execution of the works and for the proper operation of the installation, whether or not these sundry components are mentioned in detail in the tender documents issued in connection with the contract.

1.1.4 Items listed in the contract documents or otherwise indicated will be supplied to the Contractor.

1.1.5 Unless otherwise indicated, work external to buildings shall include the supply and installation of:

- sand for cable bedding and cover
- cable warning covers, cable warning tapes and cable markers
- poles/posts.

1.1.6 Unless otherwise indicated, the following will be carried out by others:

- trenching, hole digging and backfilling
- duct laying and construction of cable drawpits
- builders work.

1.1.7 Drawings and documents shall be provided by the Contractor in accordance with Section 20.

1.1.8 Adequate protection of equipment during transit shall be provided by Manufacturers and the Contractor shall ensure adequate protection on site. The Contractor shall advise the Project Manager of any damage that occurs to equipment including finishes and shall carry out repairs as directed by the Project Manager.

1.2 RELATED DOCUMENTS

1.2.1 Related documents will be enumerated in the invitation to tender or in an appendix to the "particular clauses". They will include the conditions of contract, particular clauses and any supplementary specifications, schedules and drawings that relate to the contract.

1.2.2 If any discrepancy is found between this Specification and the related documents, regulations or standards, the appropriate Officer shall be informed. During the tender stage and prior to a contract being placed the Officer shall be as listed in the documents; thereafter the Project Manager shall be consulted.

1.3 DEFINITIONS

1.3.1 The definitions in BS 7671:2001 apply throughout this Specification.

1.3.2 Where work is undertaken as a Subcontract, "Contractor" shall mean "Subcontractor".

1.3.3 The words "as indicated", "where indicated", "unless otherwise indicated", refer to items or requirements indicated elsewhere in the tender documents issued in connection with the contract, for example on a drawing, in a supplementary specification or schedule.

1.3.4 "Project Manager" shall mean an official of the MOD or commercial representative responsible for the purpose of management and administration of the works covered within this Specification.

1.3.5 The Project Manager shall, where required, consult with competent persons to ensure that deviations from specification are satisfactory. Alternatives may be used with the specific written approval of the Project Manager.

1.4 REGULATIONS

1.4.1 Each installation shall comply with all relevant statutory instruments and regulations including, but not limited to, the following:

- Electricity at Work Regulations 1989
- Electricity Supply Regulations 1988
- Health and Safety at Work etc. Act 1974
- Construction (Design and Management) Regulations 1994
- BS 7671:2001 Requirements for Electrical Installations
- requirements of the local electricity, telecommunications, gas and water Suppliers;
- COSHH Regulations 2002
- Construction (Working Places) Regulations 1966
- Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEAR)
- Electrical safety quality and continuity regulations 2002.

EU Directives implemented into British regulations.

In addition the guidance published in the Institution of Electrical Engineers (IEE) Guidance Notes shall be followed.

1.4.2 The Contractor shall fulfil the relevant duties under the Construction (Design and Management) Regulations as Principal Contractor or shall co-ordinate with the Principal Contractor as appropriate.

1.5 STANDARDS

1.5.1 The complete installation shall comply with all relevant British Standards and, where indicated, with other Standards and Specifications, and all amendments thereto. The relevant issues shall be those current three months before the date for return of tender, unless alternative dates are indicated.

1.5.2 Where practicable, each item of equipment shall be clearly and indelibly marked to indicate the standard with which it complies. Alternatively a Certificate of Compliance shall be provided for the Project Manager, to be included in the handover documentation.

1.5.3 Where equipment or services are indicated to be manufactured or provided under a particular certification, licensing or quality assurance scheme, the Manufacturer or Supplier shall be a current participant in the relevant scheme. A Certificate of Compliance shall be provided for the Project Manager, to be included in the handover documentation

1.5.4 Equipment supplied shall be of a standard that ensures its compliance with all appropriate British Standards and EU requirements.

1.6 APPROVAL

1.6.1 The Project Manager's approval shall not relieve the Contractor of his contractual responsibilities and obligations. The Contractor shall be responsible for discrepancies, errors or omissions on drawings or other documentation supplied by him, whether they have been approved by the Project Manager or not, provided such discrepancies, errors or omissions are not due to incorrect information given in writing by the Project Manager. The Contractor shall be responsible for ensuring that equipment complies with the specified requirements.

Section Two – Power Distribution Equipment

2.1 ELECTRICAL CHARACTERISTICS OF ASSEMBLIES

2.1.1 The electrical characteristics of component parts of assemblies shall apply when the components are mounted in their enclosures, appropriate derating factors having been allowed for the effect of the enclosures, other components and interconnections.

2.1.2 Site built assemblies shall not be allowed except with the express written approval of the Project Manager.

2.2 ENCLOSURES OF ASSEMBLIES

2.2.1 Doors shall have fastenings with provision for locking in the closed position, or shall require a special tool for opening.

2.2.2 Fixing holes for equipment inside buildings may be inside or outside the enclosure. Equipment to be located outside buildings shall have fixing lugs external to the enclosure.

2.2.3 Earthing terminals shall be appropriately fitted to each enclosure, suitable for internal and external connection, to enable the exposed conductive parts of the factory built assembly to be connected to a protective conductor. Where the enclosure has a painted finish, provision shall be made for the earthing terminal to be electrically connected to the enclosure without the need to remove any paint from ferrous metal.

2.2.4 Adequate spacing shall be allowed for spreading of cable tails to avoid stress on the insulation or terminals; if necessary, proprietary extension boxes shall be fitted to standard enclosures.

2.2.5 Gland plates shall be provided as appropriate for the type of cable to be connected. For single-core cables, non-ferrous gland plates shall be provided, and there shall be a clearance of not less than 25mm between cable glands and ferrous metal.

2.2.6 Ferrous parts of enclosures located outside buildings or at other locations, as indicated, shall be protected against corrosion by a hot-dip galvanised coating to BS EN ISO 1461 or by a zinc sprayed coating to BS EN 22063 with the Manufacturer's standard finish or as indicated.

2.2.7 The resins and dyes used in the manufacture of Glass Reinforced Plastic (GRP) enclosures shall be able to withstand continuously a temperature of 50°C.

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

2.3 BUSBAR TRUNKING SYSTEMS

2.3.1 Busbar trunking systems shall comply with BS EN 60439-2 and clauses 2.1 and 2.2. They shall have a fault withstand current as indicated.

2.3.2 Busbar trunking systems shall be suitable for mechanical loads as defined in BS EN 60439-2, and they shall not be used to support other equipment.

2.3.3 A means of isolation shall be provided; the number of poles shall be as indicated.

2.3.4 The phase sequence shall be maintained along the entire length of each busbar trunking system and shall be identical in all systems in the installation. Phase colour shall be clearly and permanently marked in each trunking unit.

2.3.5 Conductors shall be supported by high grade non-hygroscopic and non-tracking insulating material. They shall be anchored in at least one position and a means of taking up expansion and contraction incorporated.

2.3.6 Tap-off points, where indicated, shall be provided with covers or shutters to screen entry to live conductors when the position is not occupied with a tap-off unit. Tap-off units shall be provided as indicated.

2.3.7 Where the enclosure is of metal it shall be continuously connected and bonded as an exposed conductive part. An earth continuity conductor shall be provided and bonded to an earthing terminal fitted to each trunking unit forming the system and to the protective conductor of the incoming cable at the feeder unit.

2.3.8 The length of busbar trunking systems shall be determined from drawings for tender purposes, but all measurements shall be checked on site prior to manufacture or installation.

2.4 DISTRIBUTION BOARDS

2.4.1 Fuseboards and miniature circuit-breaker boards shall comply with BS EN 60439-3 and clauses 2.1 and 2.2. Fuses and miniature circuit breakers shall comply with clauses 2.7 and 2.8 and shall be as indicated.

2.4.2 Fuseboards shall be shielded or shrouded to meet at least IP2X standard.

2.4.3 In distribution boards neutral busbars and earth bars shall have at least one outgoing terminal for each outgoing circuit. Consideration of the requirements for high leakage current installations shall be given.

2.4.4 A multi-terminal bar for the circuit protective conductors shall be provided for both insulated and metal cased distribution boards. It shall be directly connected to the earthing terminal without dependence on the exposed conductive parts of the enclosure.

2.4.5 Identification of each fuseway and Miniature Circuit Breaker (MCB) way shall be by permanent numbering. Identification on the neutral busbar and protective conductor bar shall clearly relate each terminal to its respective fuseway or MCB way.

2.4.6 10% spare fuseways or MCB ways shall be provided unless otherwise indicated. Where specific ratings are indicated, fuses or MCB's shall be incorporated, otherwise the ways shall be provided with proprietary covers suitable for future additions.

2.4.7 Each distribution board shall be fitted with a means of isolation.

2.5 AIR-BREAK SWITCHES

2.5.1 Air-break switches shall comply with BS EN 60947-3 and clause 2.1 and have a utilisation category of AC-22 or AC-23 as indicated. Other characteristics of the equipment shall be as indicated.

2.5.2 All switches including fuse combination units shall meet the requirements for switch-disconnectors.

2.5.3 Switches used as motor starters shall be to Appendix A of BS EN 60947-3.

2.5.4 Operating mechanisms shall be independent manual or as indicated.

2.5.5 Where indicated auxiliary contacts shall be incorporated in switches.

2.5.6 Each switch shall have a facility for padlocking in the "OFF" position.

2.5.7 Fuse combination units shall be fitted with fuses complying with clause 2.7.3.

2.5.8 Enclosures shall comply with clause 2.2.

2.6 MOULDED-CASE CIRCUIT-BREAKERS

2.6.1 Moulded-case circuit breakers shall comply with BS EN 60947-2 and clause 2.1. They shall have the voltage and current ratings, rated duty and rated short-circuit breaking capacity as indicated. The rated short-time withstand time shall be one second unless otherwise indicated.

2.6.2 MCCBs shall be of the independent manual closing air-break type, rated for an uninterrupted duty, unless otherwise indicated.

2.6.3 Auxiliary facilities, including power closing and undervoltage releases, shall be provided only as indicated.

2.6.4 Each MCCB shall have a facility for padlocking in the "OFF" position.

2.6.5 Enclosures shall comply with clause 2.2.

2.7 FUSES

2.7.1 The type and current rating of fuses shall be as indicated.

2.7.2 Cartridge fuse links complying with BS 1361 shall be Type I. Fuse carriers, bases and associated parts shall also comply with BS 1361.

2.7.3 Cartridge fuse links complying with BS 88/BS EN 60269 shall be Class gG (or Class gM in motor circuits) unless otherwise indicated. Motor circuit fuse links shall be used only where indicated. Fuse carriers, bases and associated parts shall also comply with BS 88.

2.8 MINIATURE CIRCUIT-BREAKERS (MCBs)

2.8.1 MCBs shall comply with BS EN 60898 and clause 2.1. They shall have the voltage and current ratings and the category of duty, and be of the type, as indicated.

2.9 RESIDUAL CURRENT-OPERATED CIRCUIT-BREAKERS (RCBO)

2.9.1 RCBO's shall comply with BS EN 61008 (RCCB's) or BS EN 61009 (RCBO's) as appropriate. The rated voltage, rated current, rated tripping current and rated breaking capacity shall be as indicated.

2.9.2 Where indicated RCCB/RCBO's shall have electronically amplified sensors. They shall be of the instantaneous, inverse definite minimum time (IDMT) or fixed time delay type as indicated.

2.10 CONTACTORS

2.10.1 Contactors shall comply with BS EN 60947-4-1 and clause 2.1. They shall be air-break type and have the voltage and current ratings, type of duty, utilisation category and electrical endurance as indicated.

2.10.2 Contactors shall be electromagnetic, suitable for the control arrangement as indicated. Operating coils shall be suitable for alternating current (ac) unless otherwise indicated, and shall be protected by cartridge fuses. Latch-in contactors shall be provided only where indicated.

2.10.3 Enclosures shall comply with clause 2.2. Inbuilt isolating switches complying with clause 2.5 and selector/test switches shall be fitted, as indicated.

2.11 FRAMEWORK

2.11.1 Frameworks for supporting electrical equipment shall be constructed from mild steel plate and strip, cold and hot rolled steel sections or slotted angles, complying with BS EN 10162, 10111, BS 4345 and BS EN 10025, 10113, 10130, 10131 or 10149 as appropriate. Metal-arc welding shall comply with BS EN 1011.

2.11.2 Frameworks mounted within a building shall have a galvanised finish with a coating equivalent to, and not less than, type Z275 to BS EN 10147, but Manufacturers' standard finishes will be accepted for slotted angles. All metal exposed during fabrication shall be given a coat of zinc-rich paint, brushed on, and finished matching the Manufacturers' finish.

2.11.3 Frameworks mounted outside a building or at other locations as indicated shall be hot-dip galvanised to BS EN ISO 1461 or sheradize coated to BS 4921. Metal exposed during fabrication shall be cleaned with a wire brush and given a coat of zinc-rich paint, brushed on.

2.11.4 Bolts, nuts, washers and screws shall be non-corrosive and compatible with the environment in which they are installed.

2.12 ERECTION

2.12.1 Equipment, including associated accessories, shall be fixed independently of the wiring system. All fixing bolts, nuts, washers and screws shall be non-corrosive and suitable for the environment in which they are installed.

2.12.2 Equipment shall be located so that a clear working space for operation, inspection and maintenance is provided. Minimum dimensions shall be in accordance with the recommendations contained in Defence Works Functional Standard Design and Maintenance Guide 08: Space requirements for plant access, operation and maintenance. In the case of cupboards which are too shallow to meet the requirement with the doors closed, equipment shall be located in the elevation area of the clear door opening.

2.12.3 Single items of equipment shall be mounted 1450mm above finished floor level to the centre of the equipment, unless otherwise indicated. Groups of equipment, other than floor standing, factory-built assemblies, shall be arranged so that no part of the equipment requiring access for operation or maintenance shall be less than 500mm or more than 2000mm above finished floor level, unless otherwise indicated.

2.12.4 The suitability of equipment to fit into the available space shall be checked before it is ordered. Where the requirements of clauses 2.12.2 or 2.12.3

are unable to be met, the Project Manager shall be consulted.

2.13 MARKING AND NOTICES

2.13.1 All diagrams, charts, tables and the wording for labels and notices shall be submitted for the approval of the Project Manager before they are installed.

2.13.2 Identification labels shall be fixed to the outside of equipment enclosures. Label format and materials shall be appropriate to the installation and shall be fixed by non-corrosive materials appropriate to the intended application and location.

2.13.3 Characters for labels fixed on the means of isolation at the origin of each installation shall be at least 10mm high and 1.5mm thick. On all other labels characters shall be at least 4mm high and 0.5mm thick.

2.13.4 Where there are two or more incoming supplies this shall be clearly indicated at each point of isolation. Labels on single-phase equipment supplied from a three-phase supply shall indicate the phase to which it is connected.

Section Three – Power Distribution Cables

3.1 CABLES

3.1.1 The type, size and conductor material of power cables shall be as indicated.

3.1.2 Paper-insulated cables up to, and including, 11kV shall comply with BS 6480; they shall be mass-impregnated, non-draining, belted type. Sheaths shall be of lead for armoured cables and lead alloy for unarmoured cables.

3.1.3 Paper-insulated aluminium sheath cables up to, and including, 11kV shall comply with BS 6480 as far as it is applicable.

3.1.4 Combined neutral/earth (CNE) cables up to and including, 1kV shall comply with Electricity Association Technical Standard 09-9 for Waveconal cable. They shall be used in TN-C-S systems only.

3.1.5 Thermosetting (XLPE or EPR) insulated cables above 6.6kV and up to, and including, 33kV shall comply with IEC Standard 60 502 or BS 6622.

3.1.6 Thermosetting (XLPE) insulated cables up to, and including, 3.3kV shall comply with BS 5467, BS 7889 or BS 6724 as appropriate.

3.1.7 Thermoplastic (PVC) insulated cable up to, and including, 3.3kV, and armoured with wire or aluminium strip, shall comply with BS 6346.

3.1.8 Cables complying with Sections 8 and 10 may also be indicated for power distribution.

3.1.9 Reduced neutral conductors shall not be used unless indicated.

3.1.10 An oversheath or serving, of the Manufacturer's standard colour for LV cables and red for HV cables, shall be provided unless otherwise indicated.

3.1.11 Installation of cables shall comply with Section 6.

3.2 JOINTING AND TERMINATING CABLES

3.2.1 Joints and terminations shall comply with clauses 3.2.2 to 3.2.12 inclusive, and with clauses 3.3 to 3.9 inclusive as appropriate to the type of cable. All joint and termination equipment shall be used to the Manufacturer's recommendations. The Project Manager shall be consulted where it is proposed to install joints that are not indicated.

3.2.2 The Project Manager shall be given evidence that the joint or termination Manufacturer has stated that the materials to be employed are suitable for the type of cable to be jointed or terminated.

3.2.3 A cable shall not be cut until the jointing or terminating commences and the work shall proceed continuously until it is completed. All necessary precautions shall be taken to prevent damage and ingress of moisture and impurities. Cable ends shall be free from moisture before jointing commences and a sample of paper from paper-insulated cables shall be tested for moisture. Where circumstances prevent completion the cable ends shall be sealed. This shall be by plumbing of lead sheathed cables and by hermetically sealing aluminium sheathed cables. For polymeric cables with polymeric oversheaths appropriate heatshrink or cold applied end caps shall be used.

3.2.4 The Contractor shall employ staff who are fully qualified and competent for the types of joints and terminations to be made. Jointers employed for both LV and HV work must produce evidence of training by the Manufacturer or an appropriate training authority in the completion of LV or HV joints and terminations as appropriate.

3.2.5 Core identification shall be matched at each joint without twisting or crossing of the cores. Where numbered cores are jointed to coloured cores, the system adopted shall be consistent throughout all cable runs and, on sites with existing installations, consistent with the system already in use. The location of the joint shall be recorded and included in the handover documentation.

3.2.6 At the last joint in an HV run or in an appropriately sized end box where phasing-out is to be done, the joint or final connection shall not be made until the Project Manager or his competent representative has witnessed, and approved, the phasing-out.

3.2.7 Joints selected for use with armoured cables shall not reduce the fault current withstand capacity nor increase the impedance of the circuit protective conductor (CPC) and shall be of a type approved by the Project Manager.

3.2.8 Armouring and metal sheaths shall be connected by a bonding conductor directly to the external earthing terminal of the equipment at all terminations. The cross sectional area of bonding conductors for LV cables shall be calculated or sized in accordance with Table 54G of BS 7671: and HV cables it shall be to BS 7197. Metal sheaths of single core cables shall be bonded and earthed at one point only, unless indicated otherwise, and insulated glands shall be used at the open-circuit end or ends.

3.2.9 Cable tails at terminations shall be formed by separating and bringing out the cores. Each tail shall be long enough to connect to the terminals of the equipment.

3.2.10 At the terminations of single core cables, gland plates shall comply with clause 2.2.5. For three phase circuits the phase conductors shall be arranged, where practical, in trefoil formation where they pass through enclosures of equipment.

3.2.11 Core identification at LV terminations shall be by coloured or numbered plastic stretch or shrink ferrules on the cores. For HV and LV terminations coloured or numbered discs shall be provided on the outside of sealing boxes to indicate the disposition of the phases and neutral conductors inside. Insulating tape shall not be used for marking cables inside joints or terminations.

3.2.12 Continuity of spare cores shall be maintained at joints, and at terminations the cores shall be connected to earth at the supply end and in a spare terminal at the load end.

3.3 CONNECTING AND TERMINATING CONDUCTORS

3.3.1 All connections and terminations shall normally be by means of compression fittings. Solder may be used only for connecting or terminating paper-insulated cables. Mechanical connectors may only be used where the Manufacturer of the joint or termination has confirmed, in writing, the suitability of the chosen connector for use with their product.

3.3.2 Cable soldering sockets shall be of correct size for the conductor without excessive clearance.

3.3.3 Compression connectors and associated dies for the compression tool shall be the correct type and size. The tool shall be so designed that the correct compression must be applied before it can be released.

3.4 SLEEVES, TAPES AND SEALING COMPOUNDS

3.4.1 Sleeves shall be of the shrink type, applied to the Manufacturers' recommendations. They shall provide sufficient thickness of insulation to suit the particular application.

3.4.2 Insulating tapes used in joints and terminations shall be compatible with, and have a temperature rating and insulating property not less than, the cable insulation. They shall comply with BS 3924, but crepe paper tapes may be used for jointing paper-insulated cables.

3.4.3 Impregnated cotton tapes shall be double selvedge.

3.4.4 All tapes shall be stored in sealed containers until required.

3.4.5 Resin fillings should, as far as is reasonably practicable, be safe and without risk to health. Each pack shall include COSHH Regulations warnings about any hazards in its use, eg. dermatitic or toxic properties, with details of the precautions that the user must take to minimise these.

3.4.6 Hot-pouring sealing compound shall be hard setting. Selection of the compound shall take account of the ambient temperature of the installation as well as the characteristics of the joint. Voids shall not be allowed in the compound.

3.5 JOINTING PAPER-INSULATED CABLES

3.5.1 Joints shall comply with clauses 3.2, 3.3, 3.4 and the following.

3.5.2 For lead sheath cables, joints shall be made within an assembly comprising plumbed lead or copper sleeves enclosed in casting moulds for cold pouring resins.

3.5.3 For HV joints above 3.3kV, purpose-made paper tube or crepe paper tape insulation is preferred

with impregnated paper separators used with three-phase cables. Where these are not used, and for joints up to and including 3.3kV, the radial thickness of insulation over connectors shall be twice the radial thickness of the cable core insulation. The radial thickness of the belt insulation shall be equal to the radial thickness of the cable core insulation.

3.5.4 The outer protection boxes for lead sheathed cables shall be cast-iron, split type. The minimum thickness of compound between the inner joint sleeves and the box shall be 12mm. Mould boxes for cast resin joints need not have additional outer protection.

3.5.5 For screened cable, continuity of screening shall be maintained across the joint.

3.6 TERMINATING PAPER-INSULATED CABLES

3.6.1 Terminations shall comply with clauses 3.2, 3.3, 3.4 and the following.

3.6.2 A barrier against the ingress of moisture into the cable cores shall be formed below compound or shrink sleeve level. For copper conductors up to and including 70mm, the cores shall be sweated solid, and for the larger sizes and for aluminium conductors a ferrule shall be sweated onto each core. The tails shall be lapped with tape complying with clause 3.4, or covered with shrink type sleeves.

3.6.3 Shrink type sleeves may be used where the cable termination is within an equipment enclosure, unless otherwise indicated. At the entry to the enclosure the cable shall be supported by a bolt-on wiping gland at which the armouring shall terminate. The cable shall be securely supported within the enclosure.

3.6.4 End dividing boxes shall be one of the following types, as indicated:

1. Compound filled, split type, cast-iron boxes with filling holes sealed by screwed plugs or caps, and with brass wiping glands and armour clamps. Top plates shall be tapped, or provided with porcelain bushings or insulators as required. Tapped top outlets shall have a minimum of 10mm of thread.

2. Cast iron or fabricated steel cable boxes fitted to switchgear or transformers.

3.6.5 Pole mounted boxes for LV cables shall be cast-iron of the tier type, but shrink type sleeves may be used subject to the approval of the Project Manager. Fixing of pole-mounted boxes shall not require any cutting of the pole.

3.7 JOINTING AND TERMINATING THERMOSETTING AND THERMOPLASTIC (PVC) INSULATED CABLES

3.7.1 Joints and terminations for Thermosetting (XLPE/EPR) and Thermoplastic (PVC) insulated cables shall comply with clauses 3.2, 3.3 and 3.4, the appropriate Part of BS 4579, BS 7888 or BS 6910 and the following.

3.7.2 Joints shall be of the cast resin or shrink type or combination of cast resin and shrink material.

3.7.3 Armour Termination shall be by means of mechanical cable glands complying with BS 6121. For armoured cables the glands shall have an earth bond attachment. For cables with conductors larger than 35mm the earth termination shall be integral with the body of the gland. Glands used with aluminium armoured cables shall be of aluminium, but for all other situations they shall be of brass, unless otherwise indicated.

3.7.4 Shrink type or pre-moulded products may be used where an HV cable termination is within an equipment enclosure, unless otherwise indicated. At the entry to the enclosure the cable shall be supported by a mechanical cable gland complying with clause 3.7.3. The cable shall be securely supported within the enclosure.

Note: - Manufactures' advice shall be sought when replacing a compound filled termination with a heat shrink type termination to ensure compatibility between the termination type and the enclosure.

3.7.5 Shrink type or pre-moulded products may be used where a termination is pole-mounted, subject to the approval of the Project Manager. Additionally, HV cables shall be fitted with shrouds.

3.8 JOINTING CNE CABLES

3.8.1 Jointing shall comply with the clauses of this Section relevant to the type of cable. The protective conductor shall not be broken under any circumstances when making a service tee-joint.

3.9 JOINTING DISSIMILAR CABLES

3.9.1 Dissimilar cables shall be jointed only where indicated or with the approval of the Project Manager.

3.9.2 Jointing shall comply with clauses 3.2, 3.3, 3.4 and shall be suitable for the two types of cable concerned.

3.10 STOP ENDS

3.10.1 The term "STOP END" means the provision of a permanent seal in which all cores are insulated and protected so that the cable can be energised safely.

Section Four – Alarm, Control, Communication and Monitoring Cables

4.1 CABLES

4.1.1 The type and size of cables shall be as indicated. Section 4 specifies those, which will be most commonly used.

4.1.2 Thermosetting and Thermoplastic insulated and sheathed cables, with or without screening and armouring, shall comply with BS 3573.

4.1.3 Cables shall be installed in accordance with this Section, Section 6, and Sections 3, 8, 9 or 10, as appropriate.

4.2 JOINTS AND TERMINATIONS

4.2.1 Joints and terminations shall comply with clause 4.2.2, and appropriate parts of Sections 3 and 10. For coaxial cables and other special cables, joints and terminations shall comply with the Manufacturer's requirements.

4.2.2 Joints shall be located above ground unless otherwise indicated. Joint boxes shall be supported securely on short posts or other approved structures. Where joints are buried, the joint box shall be positioned a short distance from, and at right angles to, the line of the route and at the same depth as the cable.

4.3 JOINTING THERMOSETTING POLYETHYLENE-INSULATED CABLES

4.3.1 Joints shall comply with clause 4.2 and the following.

4.3.2 Joints in two-core cables shall be made in adaptable boxes complying with clause 8.3. Cables shall be terminated at the boxes with compression glands and armour clamping cones. Joints in conductors shall be made using insulated terminal blocks complying with the requirements of clause 12.19. Boxes shall be filled with an inert, permanently plastic compound having a high insulation value, and shall be completely wrapped in Thermoplastic (PVC) self-adhesive tape or similar.

4.3.3 Joints in multi-pair cables with 20 or fewer pairs, including tee-joints having a branch cable of not more than four cores, shall be made in single ended bell-type boxes with expanding plug assemblies. The complete cable, including the armouring and outer sheath, shall be clamped in a neoprene expander plug.

4.3.4 Joints in cables having more than 20 pairs, including tee-joints having a branch cable of not more than four cores, shall be made as indicated. Approved sleeve type boxes complying with the cable Manufacturer's recommendations shall be used.

4.3.5 Link disconnecting units located above ground shall be used where tee-joints having a branch cable of more than four cores are to be made.

4.4 TERMINATING THERMOPLASTIC (POLYETHYLENE) INSULATED CABLES

4.4.1 Terminations shall comply with clause 4.2 and the following.

4.4.2 Cables shall be terminated at link disconnecting units (LDU), which shall be supplied complete with terminal strips and compression glands.

4.4.3 The armouring of all cables entering the LDU shall be bonded together, unless otherwise indicated. The conductivity of the bonding conductor shall be not less than the conductivity of the armouring of the largest cable.

4.5 JOINTING THERMOSETTING (POLYETHYLENE) INSULATED CABLES TO PAPER-INSULATED CABLES

4.5.1 Joints shall comply with clauses 4.2 and shall be made using single ended bell-type boxes with expanding plug assemblies.

4.5.2 The finished joints shall be filled with an inert, permanently plastic compound having a high insulation value.

4.6 SEGREGATION

4.6.1 Segregation of cables from those of other systems and from equipment, pipework and ductwork shall comply with clause 6.2 and with any additional requirements that are othewise indicated. Any requirements that are indicated for segregating circuits of particular systems shall be observed.

4.6.2 Band 2 cables shall not be installed in the same conduits, trunking compartments or cable ducting compartments as Band 1 cables, unless otherwise indicated, and any requirements that are indicated for segregating circuits of particular systems shall be observed.

4.7 MARKING

4.7.1 Marking of cables and the termination of conductors shall comply with clause 6.11, 8.1.5, 9.1.2 and 10.6.9 as appropriate, to the type of cable.

4.7.2 A label indicating the system concerned shall identify all joint boxes. Labels shall be in accordance with clause 2.13.

4.7.3 A diagram showing the allocation of terminals for each incoming cable shall be permanently fixed inside each joint box cover. The diagram shall be afforded protection suitable for the environment in which it is located.

Section Five – Cable Supports

5.1 SELECTION OF CABLE SUPPORTS

5.1.1 The type and sizes of cable support systems shall be selected by the Contractor to suit the circumstances of the installation, unless otherwise indicated. They shall also comply with clauses 5.2 to 5.8 inclusive, and the following preferences shall be taken into account:

- for horizontal runs - cable tray or cable rack
- for vertical runs - cable cleats or cable tray or cable rack.

Where marshalling of cables occurs (eg. at switchboards) - cable racks.

5.1.2 The selection, sizing and installation of cable supports shall take account of the requirements of Section 6.

5.2 PROTECTIVE FINISHES FOR FERROUS MATERIALS

5.2.1 All ferrous metal for cable tray, cable racks, cable ladder, cable hangers and their fixings and suspensions shall have a galvanised finish.

5.2.2 Galvanised finishes shall be hot dipped to BS EN ISO 1461, except that support steelwork in dry indoor unpolluted areas shall be galvanised to Z275 of BS EN 10147.

5.2.3 In offshore, coastal and polluted areas where ferrous materials are used, consideration shall be given to the use of stainless steel or silicon steel with 1200 g/m^2 coating to BS EN ISO 1461.

5.3 CABLE TRAY

5.3.1 Cable tray shall be metal, plastic or GRP, as indicated. Metal cable tray shall comply with clauses 5.2 and 5.3.2 to 5.3.8. Steel mesh basket trays may be used only for data, communications, alarm and similar wiring systems, unless otherwise indicated.

5.3.2 Cable trays shall be perforated. Metal cable trays shall be formed from carbon steel plate complying with BS EN 10130, 10131 or 10149 as appropriate. Trays and supports shall be selected to provide adequate support without sagging more than 1/360 of the support span, or as indicated.

5.3.3 Bends, tees, risers, reducers and four-way crosspieces shall be factory made wherever possible, and shall be of the same construction, material, thickness and finish as the cable tray. All tees and crosspieces shall have a 45° gusset on each side from the point of intersection.

5.3.4 Cable trays shall be cut along a line of unperforated material. Holes cut in cable trays for the passage of cables shall be fitted with grommets, bushes or other lining. Cutting of cable trays shall be kept to a minimum.

5.3.5 Each length of a cable tray shall be securely bolted to an adjacent length with factory made couplings of adequate dimensions to prevent sagging or twisting in accordance with the Manufacturer's recommendations. Where required, bolts and nuts shall be appropriately dimensioned mushroom-head steel roofing type complying with BS 1494. Ends of coupling bolts shall not come into contact with the cables. No welding shall be used in the joining of cable trays.

5.3.6 Where cables are laid on the cable tray they shall be secured by ties, each tie securing the cables of only one circuit. The ties shall be of a proprietary type low in halogen, self extinguishing and ultra-violet resistant. The use of wire or similar material is not permitted. Ties shall be used at less than 600mm intervals along each cable, and within 100mm of each bend or set.

5.3.7 Cables shall be supported by cable cleats where cable trays are vertical. Mineral-insulated cables on vertical trays shall be supported by saddles or clips.

5.3.8 Cable trays shall be fixed at regular intervals in accordance with Manufacturer's recommendations but not exceeding 1200mm and at 225mm from bends and intersections. A minimum clear space of 25mm shall be left behind all cable trays.

5.3.9 Cable trays shall be installed with a 20mm gap at building or structural expansion joints. Cable

tray supports shall be installed within 150mm on either side of the joint.

5.4 CABLE CLEATS

5.4.1 Cable cleats shall be made from materials that are resistant to corrosion without the need for treatment or special finish. Plastic materials shall be non-brittle down to –20°C. Non-metallic cleats used for low smoke fume (LSF) cables shall be of LSF material.

5.4.2 Cable cleats shall be of a size such that they can be tightened down to grip the cables without exerting undue pressure or strain on them. For vertical cables two-bolt cable cleats shall be used which shall grip the cables firmly enough to prevent them slipping.

5.4.3 The spacing of cable cleats shall comply with the IEE Guidance Notes to BS 7671. Cleats shall be located immediately on each side of bends in the cable.

5.4.4 Single core cables shall be cleated with trefoil cleats, where appropriate.

5.5 CABLE RACKS AND CABLE LADDERS

5.5.1 Cable racks shall comply with clause 5.2 and shall be constructed from proprietary systems using channel sections with return lips and compatible fixing accessories.

5.5.2 Ladder rack shall be factory made from steel complying with clause 5.2.

5.5.3 Racks and supports shall be selected to provide adequate support without racks sagging more than 1/360 of the support span, or as indicated.

5.5.4 Cable racks and ladders shall be installed with a 20mm gap at building or structural expansion joints. Supports shall be installed within 150mm on either side of the joint.

5.5.5 Cables shall be fixed to racks and ladders by cable cleats.

5.6 CABLE HANGERS

5.6.1 Cable hangers shall be used only where indicated. They shall be made from mild steel flat bar complying with clause 5.2.

5.7 SUSPENSION AND FIXINGS

5.7.1 Proprietary suspension systems comprising channel sections with return lips and compatible fixing accessories or slotted angles complying with BS 6946 shall be used. Fixings may be fabricated from mild steel flat bar where necessary. Metal arc welding shall comply with BS EN 1011.

5.7.2 Fixing to the building fabric shall comply with Table 5A, unless otherwise indicated.

5.7.3 No shot firing shall be used and no drilling or welding of structural steelwork shall be done without the approval of the Project Manager.

5.7.4 Suspensions and fixings shall comply with clause 5.2.

5.7.5 Bolts, nuts, washers and screws shall be non-corrosive and compatible with the environment in which they are installed.

5.8 BONDING

5.8.1 Metallic cable trays, racks and ladders shall be electrically and mechanically continuous throughout and bonded to the earth system.

5.8.2 Supplementary bonding shall be installed wherever necessary, between component parts of cable trays, racks or ladders where the method of mechanical connection does not provide permanent and reliable metal-to-metal joints of negligible impedance. An earth bonding strip having a minimum cross section of 6mm^2 shall be installed across the gap at building or structural expansion joints.

TABLE 5A FIXING FOR CABLE SUPPORTS

Building Fabric	Type of Fixing
Structural steelwork	Purpose made clamps, the type to be approved by the Project Manager.
Non-structural steelwork	As for structural steelwork, or bolts, washers and nuts
Concrete, brick or building blocks	Expanding anchors, or screws and plugs, to be approved by the Project Manager.
Timber	Coach Bolts

Section Six - Cable Installation

6.1 ROUTES

6.1.1 Unless the routes of cables are indicated on the drawings they shall be determined by the Contractor and approved by the Project Manager before work is started.

6.1.2 Cables installed on the surface shall be parallel with the lines of the building construction and properly aligned.

6.1.3 Cables buried below ground shall, as far as practicable, follow the features of the site such as roadways and building lines. Ducts at road and rail crossings shall normally be at right angles to the line of the road.

6.2 SEGREGATION

6.2.1 A minimum clearance in accordance with Table 6A shall be allowed from any equipment, pipework or ductwork. The distance shall be measured from the external surface of any lagging. In the event of difficulty in achieving these requirements the Project Manager shall be consulted.

6.2.2 Spacing between cables shall comply with Table 6A and be arranged so that the grouping factor used in the cable calculations shall not be affected. In the event of difficulty in achieving these requirements the Project Manager shall be consulted.

6.2.3 Where indicated, space shall be allowed along cable routes for future additions, and cable supports shall be of adequate size for the ultimate load.

6.2.4 Adequate space shall be left between cable runs and the building fabric and other services to allow for the future removal or installation of cables.

6.3 SUPPORTS AND FIXINGS

6.3.1 Cables shall be adequately supported, by one of the methods specified in Section 5, throughout their length except where they run through cable ducts or are buried direct in the ground. Fixing direct to the building fabric by cable cleats may be adopted for single runs subject to the approval of the Project Manager, and where indicated.

6.3.2 Where cables are not continuously supported, the supports shall be spaced to the cable Manufacturer's recommendations.

6.3.3 Cables shall be supported within 300mm of their termination at equipment. The weight of a cable shall not be carried by a terminal box or gland. The distance may be increased to suit the requirements of clause 13.11.

6.3.4 Where cables cross expansion and settlement joints in the building structure they shall be fixed 300mm each side of the joint and sufficient slack left between to allow for movement. Where the cables are buried in the building fabric, suitable provision shall be made to allow for movement of the structure. The Contractor shall submit his proposals for the approval of the Project Manager.

6.4 TRENCHING

6.4.1 No work shall commence until the Contractor has taken all reasonable steps to ensure that the area is free of all cables, drains and other services, or that the location has been determined of those services known to exist. Health and Safety Executive publication HS(G) 47 gives guidance for avoiding underground services.

6.4.2 Unless otherwise indicated, excavations within 600mm of existing services shall be by hand digging. All services uncovered, whether expected or not, shall be reported immediately to the Project Manager, and they shall be supported by slings or other suitable means and protected. Any damage to services, however minor, shall be reported immediately to the Project Manager. No repairs or replacement shall be done unless the Project Manager gives approval.

6.4.3 When cable trenches are opened, all necessary safety precautions shall be taken to prevent accidents and damage occurring. Cables shall be laid expediently with regard to project requirements. The Project Manager's approval shall be obtained before a trench is backfilled. Ideally

backfilling shall be commenced within 24 hours of cable laying and the work completed speedily.

6.4.4 Cables shall be buried at a sufficient depth to avoid being damaged by any disturbance of the ground reasonably likely to occur. Trenches shall be excavated to such depth but not less than specified in Table 6B.

6.4.5 Turf and topsoil shall be removed carefully and preserved for reinstatement in their original positions. Spoil from the trench intended for re use as reinstatement material shall be removed from the lip of the trench by at least 150 mm.

6.4.6 Excavations shall be carried out in accordance with BS 6031, BS 8000 Part 1 and shall comply with the Construction (Working Places) Regulations, 1966 and all other relevant statutory requirements. Excavations shall be kept free of water and protected against damage or collapse. The safety of persons and the protection of structures, buildings, roads, sewers and services from damage shall be ensured. All necessary sheeting, timbering, strutting and shoring shall be supplied, erected and subsequently removed.

6.4.7 Before cables are laid, the bottom of the trench shall be graded evenly, cleared of loose stones and then covered for the full width of the trench with a 75mm layer of compacted sieved sand. Where the level of the trench bottom has to change the slope shall not be greater than 1 in 12.

6.4.8 After cables have been laid a further layer of sieved sand shall be added over the full width of the trench, and tamped to provide finally not less than 50mm cover over the cables.

6.4.9 Trenches shall be backfilled in layers and each layer shall be rammed. The first two layers shall be 100mm deep and rammed by hand; the remaining layers shall be not less than 200mm deep and power ramming may be used. Warning tapes and covers shall be included as specified in clause 6.5. Where applicable, topsoil and turf shall be replaced and the final level shall be level with, or not more than, 25mm above, the adjacent ground level. A higher degree of consolidation is required for excavations within shoulders and over-runs and adjacent to paved areas used by aircraft. At these locations the final layer of reinstatement shall be compacted by power ramming until maximum possible compaction is achieved.

6.5 WARNING TAPES AND COVERS

6.5.1 A warning tape shall be placed above each cable that is laid direct in the ground and above each cable duct. The tape shall be laid at a depth of 300mm below the finished surface level except where the depth of roadway or paved area base exceeds 300mm in which case the tape shall be laid immediately below the base.

6.5.2 Warning tapes shall be of polythene not less than 150mm wide and 0.1mm thick. They shall be yellow in colour and bear the continuously repeated legend "CAUTION ELECTRIC CABLE BELOW", or similar, in black letters not less than 30mm high.

6.5.3 Interlocking cable warning covers shall be provided for HV cables and for mineral-insulated cables. For other cables they shall be provided only where indicated. They shall be of proprietary manufacture and shall be laid directly on the tamped sand that covers the cables.

6.6 DUCTS

6.6.1 Cables shall be installed in cable ducts where they pass under, or within, 5m of railway tracks, where they pass under roadways or other areas with vehicular access, where they are supported on bridges, where they enter buildings, and additionally where indicated.

6.6.2 Cables shall be protected by steel tubes on bridges. All other cable ducts shall be selected by the Contractor from the alternatives listed in clauses 6.6.4 to 6.6.6 to suit the circumstances of the installation, unless otherwise indicated.

6.6.3 Ducts shall be of a size suitable for the cables to be drawn-in and withdrawn without damage. The minimum size of bore shall be 100mm. The bore shall be smooth and entirely free from rough spots, sharp edges, imperfections and protuberances.

6.6.4 Cable ducts of vitrified clay shall comply with BS 65 and shall be extra strength class. They shall be joined with plastic flexible sleeves to provide self-alignment of the bore.

6.6.5 Thermoplastic (PVC) ducts shall be unplasticized Thermoplastic (PVC) pipe complying either with BS 4660 or BS 5481 as appropriate, or with BS 3506 classes B, C, D or E. They shall have rubber sealing rings complying with BS EN 681. Thermoplastic (PVC) ducts shall not be used where the depth of cover exceeds 1m.

6.6.6 Steel tubes shall comply with BS 1387 and shall have screwed socket joints and end bushes. Tubes shall be protected against corrosion with a coat of bitumastic paint before they are installed. Tubes of 100mm bore shall be of light thickness; above this size they shall be medium thickness.

6.7 LAYING OF DUCTS

6.7.1 Unless otherwise indicated, cable ducts shall be laid at depths which comply with the requirements of Table 6B.

6.7.2 The bottom of trenches shall be rammed to provide a flat firm bedding. Where rock is present a layer of loose soil shall be spread over the bottom and also rammed. In water-logged or unstable soil a 75mm thickness of grade 10 concrete, as defined in BS 8110, with 20mm aggregate shall be laid as a foundation and soil placed around and above to a depth of 75mm above the top of the duct.

6.7.3 Where cable ducts pass under, or within, 5m of railway tracks or under roadways, the bottom of trenches shall be rammed and the ducts laid on, and surrounded by concrete, providing a minimum cover of 150mm all around. The concrete shall be grade 20, as defined in BS 8110, with 20mm aggregate. At each joint in the ducts, flexibility shall be maintained by forming a joint in the concrete by a 25mm thick compressible foam filler.

6.7.4 Cable ducts shall extend not less than 1m beyond the limit of roadways and paved areas. They shall be at least 150mm away from gas and water pipes, drains, sewers and electrical plant. Where services cross, the clearance shall be not less than 50mm. If difficulty arises in achieving these minimum clearances the Project Manager shall be consulted.

6.7.5 Deflection from a straight line and variation in depth shall not exceed 1 in 30 horizontally nor 1 in 60 vertically and the cable duct shall pass the alignment tests.

6.7.6 Draw-pits shall be constructed at each change of direction and, for straight runs, at intervals not exceeding 25m unless otherwise indicated. Draw-pits shall be of adequate size to enable cables to be drawn-in without damage or undue stress due to bending. The construction of draw-pits and their covers shall be as indicated.

6.7.7 Concrete shall comply with BS 8110 and shall be of a class suitable for the sulphate content of the soil in accordance with Table 6.1 of the Code of Practice.

6.7.8 Alignment shall be proved by drawing a mandrel through each duct. The diameter of mandrel shall be 7mm less than the bore diameter. Mandrels shall be of wood, 250mm long.

6.7.9 While cable ducts are being laid nylon, polypropylene or similar draw-lines shall be threaded through each length of duct. The draw-lines shall have a breaking strength of not less than 550N and shall be at least 4m longer than the duct run.

6.7.10 Immediately after laying, and before backfilling the trench, the ends of the cable ducts shall be sealed temporarily with proprietary plugs. Draw-lines shall be secured outside the plugs.

6.7.11 Backfilling shall be in accordance with clause 6.4.9. Where a cable duct is not used immediately, temporary marker posts shall be installed to locate the ends of the duct and shall be retained in position until cables are drawn in. Markers shall be white painted wooden posts 75mm x 75mm, standing not less than 600mm out of the ground.

6.7.12 Ducts shall be cleared with a mandrel 150mm long and having a diameter 12mm less than the bore diameter immediately before cables are drawn-in. The mandrel shall be followed by a circular wire brush with a diameter 12mm more than the bore diameter.

6.8 HANDLING OF CABLES

6.8.1 Installation of cables shall be carried out only when the ambient temperature is above 0°C unless a written statement from the Cable Manufacturer confirms that no damage to the cable will result, and the approval of the Project Manager is given. The temperature of the cable shall have been above 0°C, or above the minimum temperature recommended by the Manufacturer, for at least 24 hours immediately prior to installation. Any special measures to achieve this shall be subject to approval by the Project Manager.

6.8.2 Cables shall be handled with care and every effort made to avoid damage to the cables, to other services and to the building fabric. Recommendations or instructions available from the cable Manufacturer concerning the installation of cables shall be taken into account. Any damage shall be reported immediately to the Project Manager.

6.8.3 Cable drums shall be unloaded carefully by means of either a crane or ramp and impact with the ground shall be avoided. They shall be supported on axles or axle stands while the cable is being pulled. Twisting and abrasion of the cable serving or oversheath shall be avoided.

6.8.4 Cables shall be pulled over cable rollers adequately spaced to prevent the cable being dragged over ground or other surface. Cable stockings shall be used for hauling cables pulled into thrust borings or cable ducts, and for all cables exceeding 10m length. Precautions shall be taken to

ensure that strain is taken on the cable cores as well as the sheath and excessive strain shall be avoided. Under no circumstances shall vehicles be used to pull cables in, appropriate cable winches or hand pulling only shall be used.

6.8.5 Cables laid in trenches shall cross other cables only at junctions. Clearances between the cables shall be maintained at crossovers. Cables shall not be laid one above the other except where indicated.

6.8.6 Only one cable shall be pulled into each duct except for the following, which may be bunched subject to the requirements of Table 6A and a maximum space factor of 20%.

Single-core cables forming one circuit;

Mineral-insulated cables;

Alarm, control, and monitoring cables;

Pilot cables associated with another power cable in the duct.

Cables that are to be installed in the same duct shall be bunched together and pulled in one operation. Additional cables shall not be drawn-in subsequently.

6.8.7 The ends of all cables shall be sealed during installation by an appropriate heatshrink or cold applied end cap, unless jointing or termination is carried out immediately. The sealed ends of power cables shall be marked with the letter "A" or "Z" to indicate the core sequence: "A" at the end where the sequence is clockwise and "Z" where it is anti-clockwise.

6.8.8 At no time shall cables be bent to a radius less than the Manufacturer's recommended minimum.

6.9 SEALING DUCTS AND OPENINGS

6.9.1 The ends of all ducts and service conduits (including spare ways) shall be sealed after cables have been installed.

6.9.2 Where ducts and service conduits enter buildings, proprietary seals shall be used to form a barrier against gas, water, oil, fire and attack by vermin. Spare ducts and service conduits shall be similarly sealed with removable material. The method of sealing shall be submitted for the Project Manager's approval before work commences.

6.9.3 Fire barriers at fire-resistant structural elements, such as floors and walls, shall satisfy the requirements of BS 476 Parts 20 and 22 for insulation, stability and integrity for the period of time indicated. The method shall be submitted for the Project Manager's approval before work commences.

6.10 CABLE GUARDS

6.10.1 Cable guards shall be fitted where cables are mounted at low level on walls, poles, towers or other locations as indicated.

6.10.2 Cable guards shall be constructed from 1.6mm thick galvanised steel sheet complying with clause 2.11 and formed into a casing with external flanges for fixing to the fabric.

6.10.3 Guards shall extend to a height of 3.5m above ground or floor level for HV cables and 1.5m for LV cables. In external locations the guards shall extend 300mm below finished ground level and they shall be protected inside and out with bitumastic paint extending from the bottom up to 150mm above finished ground level.

6.11 MARKING OF CABLES

6.11.1 Marker posts or slabs shall permanently identify the location of buried cables. The wording on the markers shall be "HV CABLE" or "LV CABLE" as appropriate; in addition the word "JOINT" shall be added where appropriate. Posts shall only be used where they do not cause obstruction or danger.

6.11.2 Cable marker slabs shall be installed, as required, flush with the finished ground level, on the precise line of the cable.

6.11.3 Cable markers shall be located at every point where a cable enters a building, sub-station, plinth or distribution pillar, at each joint, change of direction, road and pathway crossing, and along the route of the cable at intervals not exceeding 45m.

6.11.4 Cables shall be colour coded in accordance with BS 1710 except where cables are buried, located in switchrooms, in ducts and spaces designated solely for electrical services, or have orange oversheaths. Colour coding, where used, shall be conspicuous bands, not less than 100mm long, located at least once within each separate compartment through which the cables pass and at intervals not exceeding 12m.

6.11 5 Trunking or ducting shall be permanently and conspicuously identified. The method of identification shall be as indicated or approved by the Project Manager

6.11.6 Cables shall be permanently and conspicuously identified. The method of identification shall be as indicated or approved by the Project Manager.

6.11.7 Cable identification shall be located within 500mm of terminations and joints, at least once within each separate compartment through which the cables pass, at intervals not exceeding 24m, and shall coincide with the colour bands, where used. Consideration shall also be given to identifying cables at entry or exit points and where buried cables emerge from the ground.

6.11.8 Every cable end shall be provided with a means of identification showing the designation, number and cross-sectional area of cores and rated voltage of the cable.

6.12 REDUNDANT CABLES

6.12.1 Where indicated, redundant cables shall be removed or stop-ended in a manner complying with clause 3.10 and clearly marked.

6.12.2 Removed cables shall be disposed of in a manner approved by the Project Manager.

TABLE 6A MINIMUM SPACING OF CABLES

Location	Cable mm	HV mm	LV mm	Telephone mm	Co-axial mm	Equipment Pipework Ductwork mm
Buried:						
	HV	50	300	300	300	300
	LV	300	25	300	150	300
	Telephone	300	150	50	50	200
	Co-axial	300	150	150	150	200
	Fibre Optic	300	150	50	50	200
In Air:						
	HV	50	300	300	300	300
	LV	300	(see note 2)	150	150	150
	Telephone	300	150	0	0	100
	Co-axial	300	150	0	0	100

NOTES:

1. The minimum spacing apply unless otherwise indicated.
2. LV cables in air may be bunched subject to any requirements regarding segregation and installation methods set out in the BS 7671: Requirements for Electrical Installations, Guidance Note No.1, and as stated in 6.2.
3. When cables are in steel pipes the minimum spacings need not be maintained, but a minimum space of 25mm shall be left between the pipes.

TABLE 6B MINIMUM COVER FOR CABLES

Type of cable	Location and Depth of Cover			
	In open ground and under pavements mm	Under roadways mm	Under or alongside railways mm	In other situations mm
HV	800	1000	1800	As indicated
LV Telephone Co-axial Fibre Optic	500	600 (light traffic) 800 (heavy traffic)		

Section Seven – Overhead Lines

7.1 OVERHEAD LINES

7.1.1 HV overhead lines shall comply with Electricity Association Technical Standard 43-40.

7.1.2 LV overhead lines shall comply with the latest issue of Electricity Association Technical Standard 43-30.

7.2 CONNECTIONS TO BUILDINGS

7.2.1 Service lines shall be Thermoplastic (PVC) insulated cables with copper or aluminium conductors as indicated, complying with BS 6485, type 8 or 16 as appropriate for the nominal voltage of the system and BS 7884, BS 215 or BS EN 50183 as appropriate.

7.2.2 Cables from the service line termination into the building shall be single core Thermoplastic (PVC) insulated with a sheath, complying with BS 6004. Core identification colours shall extend throughout the length of the cables.

7.2.3 The Contractor shall include, for the supply and fixing of all insulators, brackets or timber posts necessary for terminating service lines at buildings, unless otherwise indicated. Brackets and fixings shall comply with Section 5.

7.3 CATENARY WIRE SUPPORTS

7.3.1 Short span overhead links between buildings shall be Thermoplastic (PVC) insulated cables complying with BS 6004, with copper or aluminium conductors as indicated. The cables shall be supported by a catenary wire which shall be preferably integral with the cable.

7.3.2 Catenary supported cables shall be installed in accordance with the BS 7671 and the IEE Guidance Notes.

7.3.3 Details of the type of catenary system and fixing to be used shall be submitted to the Project Manager, whose written approval shall be obtained before work proceeds.

Section Eight - Wiring System: Cables in Conduit, Trunking and Ducting

8.1 CABLES

8.1.1 The type and size of cables shall be as indicated. Clauses 8.1.2 to 8.1.4 specify those which will be used most commonly.

8.1.2 Thermoplastic (PVC) insulated sheathed and non-sheathed cables shall comply with BS 6004. They shall have copper conductors unless otherwise indicated.

8.1.3 LSF cables shall comply with BS 7211 and shall have copper conductors unless otherwise indicated.

8.1.4 Thermosetting (Rubber) insulated non-sheathed cables shall comply with BS 6007.

8.1.5 Core identification colours shall extend throughout the length of Thermoplastic (PVC) insulated cables. Where appropriate the colours shall be as indicated. The additional identification requirements of clause 8.12.6 shall also be met.

8.1.6 Cables shall be protected throughout their length by trunking, ducting, conduit and equipment enclosures. Framework or partitions may only be used as protection with sheathed wiring systems.

8.2 CONDUIT

8.2.1 Conduit, including flexible and pliable conduits, shall be either steel or non-metallic as indicated, and comply with the appropriate British Standards.

8.3 STEEL CONDUIT AND FITTINGS

8.3.1 Steel conduits and fittings shall be screwed classification unless otherwise indicated or approved by the Project Manager.

8.3.2 The protection against corrosion of conduits and conduit fittings for general use inside buildings shall be Class 2. For use outside buildings, in plant rooms, floor trenches, other locations as indicated and in floor screeds, the protection shall be Class 4.

8.3.3 When located outside buildings, adaptable conduit boxes and covers shall be as indicated.

8.3.4 When conduit boxes are installed flush with the building fabric, overlapping covers shall be fitted.

8.3.5 Flexible steel conduit for general use inside buildings shall be Type A with protection against corrosion equivalent to Class 2. For use in plant rooms and other locations as indicated the protection shall be Class 4. Adaptors shall be of the solid type.

8.3.6 Prewired pliable conduit systems may only be used where indicated.

8.4 NON-METALLIC CONDUIT

8.4.1 Non-metallic conduit shall be rigid heavy duty Thermoplastic (PVC) unless otherwise indicated. Joints shall be made using solvent approved by the conduit Manufacturer.

8.4.2 Pliable conduits shall be heavy duty, reinforced, unless otherwise indicated. Pliable conduit shall not be used where the ambient temperature may exceed 60°C or where mineral oils or petrol are present.

8.4.3 Flexible conduits shall be used for connections to moving or vibrating equipment.

8.5 TRUNKING AND DUCTING

8.5.1 Trunking and ducting shall be of steel or insulating material as indicated, and shall comply with BS 4678 and clauses 8.6 or 8.7 where appropriate.

8.5.2 Trunking shall provide a minimum degree of protection of IP41 when used inside buildings and shall not normally be used in wet or outdoor areas. Trunking used outside buildings, or at other locations indicated, shall provide a minimum degree of protection of IP44.

8.5.3 Partitions shall be of the same material as the trunking or ducting. The gap between partitions

and trunking covers shall be a minimum to ensure that segregation of circuits is maintained.

8.5.4 Manufacturer's proprietary fittings shall be used. Site fabricated fittings may only be used with specific written approval of the Project Manager and only where these are inadequate will site fabricated fittings be accepted. Fittings fabricated on site shall be comparable in construction with the rest of the trunking or ducting system.

8.5.5 Ends of runs shall be fitted with removable covers to permit future extension.

8.5.6 The size of trunking and ducting shall be as indicated.

8.5.7 Trunking with the cover on the side or bottom shall be fitted with removable cable retaining straps at intervals not exceeding 1m. Cables shall be supported at intervals not exceeding 3m where trunking runs vertically. The method of support shall allow for future easy removal of, or addition to, the cables and shall be submitted for the approval of the Project Manager.

8.6 STEEL TRUNKING

8.6.1 Unless otherwise indicated, the protection against corrosion for general use inside the buildings shall be Class 2; for use outside buildings, in plant rooms, floor trenches and other locations as indicated, the protection shall be Class 3.

8.6.2 Bonding links shall be provided at each joint and secured by screws, nuts and shakeproof washers. The bonding links shall make contact with the metal of the trunking or fitting, and continuity shall not depend on contact through the screws, nor on removal on site of paint finish from ferrous metal.

8.6.3 Factory made connectors shall be used at joints.

8.7 UNDERFLOOR DUCTING AND FLOOR TRUNKING

8.7.1 Protection against corrosion shall be Class 3.

8.7.2 Service outlet boxes and junction boxes shall be constructed from sheet steel of the same finish as the ducting, with top frames adjustable for height at each corner. The frames shall be cast aluminium unless otherwise indicated. Segregation of the compartments of the ducting shall be maintained through the boxes.

8.7.3 Each service outlet box shall have outlet units as indicated. The complete assembly shall comply with the requirements of BS 6701.

8.7.4 Lids of service outlet boxes and of floor trunking shall be of cast aluminium unless otherwise indicated. The lids shall be arranged to accommodate the floor finish, as indicated.

8.8 ROUTES AND SEGREGATION

8.8.1 The routes of conduit, trunking and ducting shall be as indicated. Where there is a discrepancy or omission, the route shall be determined by the Contractor and approved by the Project Manager before work is started. This requirement shall apply where the conduit, trunking or duct is concealed within the building fabric as well as where they are on the surface.

8.8.2 Conduit, trunking and ducting shall be parallel with the lines of the building construction and properly aligned, except where conduit is permitted in floor screeds. Conduit buried in wall finishes shall run vertically only, unless the Project Manager gives approval to deviate from this requirement.

8.8.3 A minimum clearance of 150mm shall be allowed from any equipment, pipework or ductwork; the distance being measured from the external surface of any lagging. In the event of difficulty in achieving this requirement the Project Manager shall be consulted.

8.8.4 Trunking shall be positioned so that adequate clearance is provided for access to the wiring. It is preferred that the covers shall be on the top or sides of the trunking, but where this is impracticable covers may be on the bottom, subject to the approval of the Project Manager. Cable support shall be as clause 8.5.7.

8.9 SUPPORTS AND FIXINGS

8.9.1 Where conduit and trunking are not fixed directly to the building fabric they shall be suspended in accordance with clause 5.7.

8.9.2 A support shall be positioned within 300mm of each bend and conduit box. Conduit boxes shall be fixed to the fabric of the building independently of the conduit. Where the conduit boxes have a minimum degree of protection of IP44 the fixings shall not reduce the protection.

8.9.3 Conduit and trunking shall be fixed in

accordance with Table 8A. No shot firing shall be used and no drilling or welding of structural steelwork shall be done without the approval of the Project Manager.

8.9.4 Screws and nuts shall be non-corrosive and compatible with the environment in which they are installed.

8.10 INSTALLATION

8.10.1 If the protective finish of any materials has been damaged, those materials shall either not be used or any remedial work shall be approved by the Project Manager before use. Conduits shall be clean and free from oil.

8.10.2 Holes in trunking shall be drilled, punched or cut by ring-saw. Trunking shall be free from sharp edges and burrs.

8.10.3 Connections between trunking and equipment shall be by screwed couplers and bushes, flanged couplings or specially fabricated connectors. Direct attachment of steel trunking to equipment will be permitted only if cable entries are provided with bushes or grommets or other lining methods approved by the Project Manager. Cutting and bending the material of trunking to form flanges for connection to equipment will not be permitted.

8.10.4 Steel conduit shall be connected by means of a coupler and an externally screwed bush at equipment not provided with screwed entries and at trunking. Bushes shall be tightened by spanners; pliers and toothed wrenches shall not be used.

8.10.5 Cable entries from trunking to distribution boards shall be adequate for cabling from all ways including spares.

8.10.6 Where a terminal block is to be accommodated in a circular box, an extension ring of sufficient depth to ensure adequate space for the terminal block and cables shall be fitted to the box.

8.10.7 The length of thread on the ends of steel conduit shall match that in the conduit fittings or equipment. Exposed thread is not permitted. Running couplings with backnuts may be used with conduit having Class 2 protection, but where the protection is Class 4 only manufactured running joints will be accepted. Exposed thread on running couplings shall be given a coat of zinc-rich plant.

8.10.8 Joints between Thermoplastic (PVC) conduit and fittings shall be made with a suitable adhesive, but expansion couplers shall be included.

8.10.9 Conduit shall be cold bent on site with a suitable bending tool, without deforming its cross section.

8.10.10 The interval between draw-in boxes in conduit systems shall not exceed the recommendations contained in BS 7671 and the IEE Guidance Notes.

8.10.11 Unless otherwise indicated, conduit buried in concrete shall have at least 30mm depth of cover and shall be securely fixed to prevent movement during pouring and vibrating of the concrete. Conduit buried in plaster shall have at least 5mm depth of cover.

8.10.12 Where conduits, trunking or ducting, cross expansion and settlement joints in the building structure, suitable provision shall be made to allow for movement of the structure. Purpose made expansion couplings shall be used in trunking. The Contractor shall submit his proposals for the approval of the Project Manager.

8.10.13 Where conduit passes through an external wall the conduit shall be plastic and a conduit box shall be fitted on the outer side of the wall. This shall be filled with an inert, permanently plastic compound having a high insulation value.

8.10.14 Conduit, trunking and ducting shall be installed in screeds only where indicated, or after receipt of the Project Manager's approval. Conduit boxes in floors, other than for agreed outlets, are not permitted.

8.10.15 Flush floor trunking and underfloor ducting shall be straight, level and adjusted in height to relate to the finished floor level.

8.10.16 Open ends of conduit and ducts shall be temporarily plugged immediately they are installed to prevent ingress of water and solid material. Flush floor trunking and the boxes of underfloor ducting shall be fitted with temporary lids immediately they are installed, and they shall be maintained as effective protection against ingress of water and solid material until the permanent lids are fitted after screeding is complete.

8.10.17 The method to be used for forming fire barriers at fire-resistant structural elements such as floors and walls shall be submitted for the Project Manager's approval.

8.10.18 Installed conduits and ducts shall be cleaned internally with a swab before cables are drawn-in.

8.10.19 If the protective finish of conduit, trunking or ducting is damaged after fixing, the

damage shall be made good in a manner approved by the Project Manager.

8.11 PROTECTIVE CONDUCTOR

8.11.1 A protective conductor shall be drawn through all conduit and trunking systems and connected to earthing terminals. Each section of trunking shall be bonded to the protective conductor. Notwithstanding the provision of a separate protective conductor the continuity of the conduit, trunking and ducting shall be to the same standard as though they were the sole protective conductors.

8.11.2 Where live conductors terminate at, or loop into, terminals adjacent to an appliance or accessory the protective conductor shall be similarly terminated.

8.11.3 The earthing terminal of a socket outlet or other accessory mounted on the lid of steel trunking shall be connected by a separate protective conductor to an earthing terminal incorporated in the fixed part of the trunking.

8.12 WIRING

8.12.1 No wiring shall be carried out until the appropriate tests required in clause 19.6.2 have been done and the Project Manager has given his clearance for wiring to commence.

8.12.2 A loop-in form of wiring shall be used as far as practicable or unless otherwise indicated. Joints in conductors shall be made using insulated terminal blocks complying with the requirements of clause 12.19.

8.12.3 Adequate slack shall be left in cables at expansion joints.

8.12.4 A draw-wire shall be installed, after swabbing, between each draw-in position where conduits are installed for wiring by others.

8.12.5 Cables forming part of alarm, control, communication or monitoring circuits shall have identification sleeves at their terminations. Identification shall be consistent with the relevant wiring diagrams.

8.13 MIGRATION OF PLASTICISER FROM THERMOPLASTIC (PVC) MATERIALS

8.13.1 Thermoplastic (PVC) sheathed cables, including thermoplastic sheath eg LSF, shall be separated from polystyrene materials to prevent the take up of the cable plasticiser by the polystyrene as this will reduce the flexibility of the cables. See Table 8B.

TABLE 8A CONDUIT AND TRUNKING FIXINGS

1. Fixing of conduit

Location	Type of Fixing
Floor screeds	Saddles
Buried in plaster or render	Crampets or saddles
Above false ceilings	Spacer bar saddles
Surface	Distance saddles

2. Fixings of saddles, conduit boxes and trunking

Building fabric	Type of fixing
Structural steelwork	Purpose made clamps, type to be approved by the Project Manager
Non-structural steelwork	Set screws and nuts
Concrete, brick or building blocks	Plugs and screws
Hollow blocks and pot floors	Butterfly spring toggle bolts or gravity bolts
Timber	Wood screws

TABLE 8B PLASTERCISER MITIGATION

Location/Fabric	Mitigation
Thermal Insulation	Thermoplastic cables shall be clipped clear of any insulation made of expanded polystyrene granules
Cable Clips	Nylon or polypropylene cable clips shall be used. Polystyrene cable clips are not to be used as they are softened by contact with thermoplastic (PVC)
Grommets	Thermoplastic (PVC) grommets should be used where appropriate. Natural rubber grommets can be softened by contact with thermoplastic (PVC). Synthetic rubbers are more resistant. Thermoplastic (PVC) grommets are not affected, but could affect other plastics.
Wood Preservatives	Thermoplastic (PVC) sheathed cables shall be covered to prevent contact with preservative fluids during application. After the solvent has evaporated, the preservative has no effect.
Creosote	Creosote shall not be applied to thermoplastic (PVC) sheathed cables as it will cause decomposition, swelling and loss of pliability.

Section Nine - Wiring System: Multi-core Sheathed Cables

9.1 CABLES

9.1.1 Cables shall comply with BS 6004, Table 5 for LV circuits and Table 4 for extra low voltage (ELV) circuits. Cables shall have copper conductors, unless otherwise indicated, and the size shall be as indicated.

9.1.2 The colour identification of cores shall comply with BS 7671 or BS EN 60446. For live conductors the identification shall extend throughout the length of the cables. The additional identification requirements of clause 9.4.12 shall also be met.

9.2 BOXES

9.2.1 Joint boxes shall comply with BS 4662 or BS 6220. Where they are of insulating material the material shall have the ignitability characteristic "P" as specified in BS 476. Where terminals are not integral, insulated terminal blocks complying with the requirements of clause 12.19 shall be used.

9.2.2 Boxes for accessories shall comply with the requirements of clause 12.1.

9.3 ROUTES AND SEGREGATION

9.3.1 Unless the routes of cables are indicated on the drawings, they shall be determined by the Contractor and approved by the Project Manager before work is started.

9.3.2 Cables shall be parallel with the lines of the building construction and properly aligned. Cables passing through joists shall comply with the requirements set down in the IEE Guidance Notes. Cables buried in wall finishes shall run vertically only, unless the Project Manager gives approval to deviate from this requirement.

9.3.3 Segregation shall comply with category "LV" in Table 6A of this specification.

9.4 INSTALLATION

9.4.1 Cables for alarm, control, communication or monitoring systems shall be fixed by proprietary saddles of suitable nylon or plastic material.

9.4.2 Cables buried in wall finishes, passing through walls or buried in concrete, including floor screeds, shall be protected throughout the length that is buried by heavy duty Thermoplastic (PVC) or metal conduit as indicated.

9.4.3 Unless otherwise indicated, conduit buried in concrete shall have at least 30mm depth of cover, and shall be securely fixed to prevent movement during pouring and vibrating of the concrete. Conduit buried in plaster shall have at least 5mm depth of cover.

9.4.4 Where conduits cross expansion and settlement joints in the building structure, suitable provision shall be made to allow for movement of the structure. The Contractor shall submit his proposals for the approval of the Project Manager.

9.4.5 Conduits entering voids shall terminate not less than 25mm clear of the building fabric. Open ends of conduit shall be temporarily plugged immediately they are installed, to prevent ingress of water and solid material.

9.4.6 Where cables pass through joists the number and size of holes shall allow for easy withdrawal and replacement of cables. The diameter of holes shall comply with the requirements set down in the IEE Guidance Notes. Joists shall not be notched.

9.4.7 The method to be used for forming fire barriers at fire-resistant structural elements such as floors and walls shall be submitted for the Project Manager's approval.

9.4.8 Where cables enter a metal enclosure they shall be protected by grommets or secured by cable clamps.

9.4.9 Cables shall be looped between outlet points, and as far as practicable, intermediate joints shall not be used.

9.4.10 Where joints are unavoidable they shall be enclosed in boxes. The box shall be permanently and clearly labelled to indicate its purpose. Traps, suitably labelled, shall be provided for permanent access where boxes are concealed. Details of the location of joints and traps shall be included in the handover documentation. No joints shall be located in concrete floors.

9.4.11 Cables fixed to the surface, except in ducts, shall be protected by high impact Thermoplastic (PVC) channels up to a height of 1.5m above floor level.

9.4.12 Cables forming part of alarm, control, communication or monitoring circuits shall have identification sleeves at their terminations. Identification shall be consistent with the relevant wiring diagrams.

9.5 PREFABRICATED WIRING INSTALLATIONS

9.5.1 The requirements of this Specification shall apply to prefabricated wiring installations.

Section Ten - Wiring System: Mineral-Insulated Cables

10.1 CABLES

10.1.1 Cables shall comply with BS 6207 Part 1. The size, conductor and sheath material and voltage rating shall be as indicated.

10.1.2 Copper sheathed cables shall have an LSF outer covering of colour from Table 10A, unless otherwise indicated.

10.2 TERMINATIONS

10.2.1 Terminations shall comply with BS 6207 Part 2 and shall be supplied by the same Manufacturer as that of the cable to which they connect, or shall be approved by the cable Manufacturer.

10.2.2 Unless otherwise indicated, seals shall have a temperature rating of 105°C. Protective conductor tails integral with the seals shall be provided, where, available from Manufacturers.

10.2.3 Appropriate glands shall be used at entries to enclosures. Where cables terminate at accessory boxes located flush in plaster finish, cable clamps may be used instead of glands; the clamps shall grip the cable sheath and shall be fixed to the accessory box.

10.2.4 Glands shall be secured with a locknut at equipment not provided with screwed entries.

10.2.5 Pressure sensitive plastic adhesive tape shall be applied over exposed cable sheaths and glands, and protected overall with an LSF shroud. The colour of shrouds shall be the same as the cable covering.

10.2.6 At the terminations of single-core cables, gland plates shall comply with clause 2.2.5. For three-phase circuits the phase conductors shall be arranged, if possible, in trefoil formation where they pass through the enclosure of the equipment.

10.2.7 Each cable tail shall be long enough to connect directly to the terminals of the equipment.

10.2.8 Compression connectors and associated dies for the compression tool shall be the correct type and size. The tool shall be so designed that the correct compression must be applied before it can be released.

10.2.9 Protective conductor tails shall be connected to earthing terminals within the enclosure. On larger sizes of cables, where tails are not provided, the metal sheath shall be connected directly to the external earthing terminal of the equipment by a bonding conductor having a cross sectional area in accordance with BS 7671.

10.2.10 Core identification shall comply with BS 7671 for Band I and Band II circuits. The additional identification requirements of clause 10.6.9 shall also be met.

10.3 JOINTS

10.3.1 Joints in cables shall be kept to a minimum. Where joints are unavoidable they shall be readily accessible for inspection.

10.3.2 Straight through joints shall be enclosed within brass jointing sleeves and the conductors shall be connected by means of solder ferrules or compression joints. Sleeves shall be made by the same Manufacturer as the cable to be jointed or shall be approved by the cable Manufacturer.

10.3.3 Joints, other than straight through, shall be enclosed in circular or adaptable conduit boxes and the conductors shall be connected by means of insulated terminal blocks. Conduit boxes shall comply with clause 8.3 and terminal blocks with clause 12.19. Terminations shall comply with clause 10.2. Conduit boxes shall be fixed to the fabric of the building or to cable tray. Where the conduit boxes have a degree of protection of IP44 or more, fixings shall not reduce that protection.

10.3.4 Joints shall not be buried in the ground except where indicated. In these cases suitable environmental protection shall be incorporated.

10.4 ROUTES AND SEGREGATION

10.4.1 The routing and segregation of cables shall comply with clauses 6.1 and 6.2, except that cables carrying negligible current may be stacked.

10.4.2 Cables shall not be buried in the building fabric except where indicated.

10.5 SUPPORTS AND FIXINGS

10.5.1 Cables shall be adequately supported throughout their length on cable tray, by fixing directly to the fabric of the building or by the means indicated, except where they run through cable ducts or are buried direct in the ground or in the fabric of the building.

10.5.2 Cables shall be supported within 300mm of their termination at equipment.

10.5.3 Cables on tray shall be laid tidily with no crossovers, except where essential, and shall be fixed with proprietary cable ties designed for the purpose, or with saddles, or clips.

10.5.4 Saddles and clips for cables having an outer covering shall be LSF covered metal. Bare copper saddles and clips may be used for cables without an outer covering.

10.5.5 The spacing of saddles and clips shall comply with the IEE Guidance Notes. Saddles or clips shall be located immediately on each side of bends in the cable.

10.5.6 Fixing of saddles to the building fabric shall be by round-head screws and to cable tray and non-structural steelwork by round-head screws and nuts. For general areas inside buildings, screws and nuts shall have appropriate non-corrosive protection and outside buildings, in plant rooms or other locations as indicated, they shall be of stainless steel or brass.

10.5.7 Fixings to building fabric shall comply with Table 10B, unless otherwise indicated. No shot firing shall be used and no drilling or welding of structural steelwork shall be done without the approval of the Project Manager.

10.6 INSTALLATION

10.6.1 The installation of cables shall comply with Section 6 as appropriate.

10.6.2 Tools for the manipulation and termination of cables shall be of a design approved by the cable Manufacturer. Corrugation of the metal sheath or damage to outer coverings will not be accepted. A wood block or wooden faced tool shall be used to finally dress cables into position.

10.6.3 Repairs to a cable's copper sheath will not be accepted regardless of the extent of the damage.

10.6.4 Terminations and joints shall be made in accordance with the Manufacturer's instructions. Only clean, dry, plastic filling compound shall be used.

10.6.5 Where cables are buried direct in the ground or in cable ducts the installation shall comply with the relevant clauses of Section 6.

10.6.6 Cables without outer covering shall not be in contact with galvanised finishes, concrete or other material that will cause corrosion.

10.6.7 Connection to appliances and motors shall comply with Section 13.

10.6.8 Cable guards shall be provided in accordance with clause 6.10.

10.6.9 Marking of cables shall comply with clause 6.11. Cables forming part of alarm, control, communication or monitoring circuits shall have identification sleeves at their termination with specific circuit identification. Identification shall be consistent with the relevant wiring diagrams.

TABLE 10A MINERAL-INSULATED CABLE SHEATH COLOURS

Circuit Type	Sheath Colour
LV power/lighting etc.	Orange
Emergency systems (emergency lighting, etc.)	Red

TABLE 10B MINERAL-INSULATED CABLE FIXINGS

Location	Type of Fixing
Structural steelwork	Purpose made clamps or fasteners, the type to be approved by the Project Manager
Non-structural steelwork	Set screws and nuts
Concrete, brick or building blocks	Plugs and round head screws
Hollow blocks	Toggle type round head screw fixings
Timber	Round head wood screws

Section Eleven – Earthing

11.1 MATERIALS

11.1.1 All materials and installations shall comply with BS 7430, the IEE Guidance Notes, appropriate parts of BS 6651, and standards quoted therein.

11.2 EARTH ELECTRODES

11.2.1 The type and number of earth electrodes shall be as indicated.

11.2.2 Unless otherwise indicated, earth electrodes shall be rods of 14mm minimum nominal diameter, extensible, copper-clad high-tensile steel rods connected together. Copper cladding shall be molecularly bonded to the steel and shall be not less than 0.25mm thick. Driving heads shall be of high-tensile steel. A corrosion inhibiting paste shall be applied to the threads on rods and couplers. Rods shall be connected by screwed joints by one of the following methods:

threads shall be roll-formed with a minimum thickness of 0.5mm copper in the roots of the thread; couplers shall be of high strength silicon-aluminium bronze alloy and all the threads shall be counterbored at the ends so that the couplers completely enclose the threads on the rods;

or

the ends of the rods shall be internally threaded; couplers shall comprise a copper ferrule with the phosphor-bronze coupler screw.

11.2.3 Where earth plates are indicated, they shall be 600mm x 600mm minimum, of solid or lattice copper not less than 3mm thick.

11.2.4 Tape for earth electrodes shall be to BS EN 13601, of the size, length, depth below ground level and layout as indicated.

11.3 CONDUCTORS

11.3.1 Earthing conductors, main earthing bars and main equipotential bonding conductors shall be of the type, size and conductor material as indicated, and shall comply with clauses 11.3.2 to 11.3.4 as appropriate.

11.3.2 Where used to interconnect copper electrodes the conductor may be bare, but for all other purposes the conductor shall have an extruded Thermoplastic (PVC) sheath.

11.3.3 Main earthing bars shall be hard drawn copper bar to BS EN 13601 Grade C101 having minimum dimensions 450mm x 50mm x 6mm.

11.3.4 Cables shall comply with BS 6004, Table 1, without sheath, or BS 7211, unless otherwise indicated.

11.4 JOINTS AND CONNECTIONS

11.4.1 Joints and connections shall be kept to a minimum.

11.4.2 All contact surfaces shall be thoroughly cleaned and coated with an anti-corrosive electrical jointing compound suitable for the conductor materials. For bi-metallic joints a separate abrasive shall be used to clean each metal.

11.4.3 Connections shall be made as follows:

to main earthing bars by bolted connection of brass, bronze or other non-ferrous conducting material, but outside buildings, in plant rooms or other locations as indicated they shall be stainless steel or phosphor-bronze set-screws and nuts;

to earth rods by bronze, gunmetal or copper clamps with phosphor-bronze bolts. Edges of clamps shall be rounded;

to earth plates by bolting, or welding.

11.4.4 Termination of cables shall be by connectors jointed to the cable conductor by the

exothermic welding process or by compression joints complying with BS 4579 and clause 3.3.3.

11.4.5 Joints which are indicated as test points shall be bolted or clamped. Joints in tape, other than at test points, shall be made by the exothermic welding process. Overlap of conductors shall be not less than 100mm.

11.4.6 Joints and connections shall be protected by a coating which will form a seal and exclude moisture in all weather conditions. At connections to earth electrodes the coating shall cover all exposed conductors. Protective coatings shall be of a waterproof, inert, tenacious material.

11.4.7 Bolts, screws, nuts, washers and rivets for copper conductors shall be of phosphor-bronze, naval brass or copper-silicon and for aluminium conductors they shall be of stainless steel. The minimum provision shall be:

for flat strip - two M8 bolts;

for sheet metal - two M8 bolts and where the sheet metal is less than 2mm thick it shall be backed for an area of at least 1000mm2.

11.5 INSPECTION PITS

11.5.1 Unless otherwise indicated, connection between an earth conductor and its associated earth electrode system shall be in an enclosure.

11.5.2 The enclosure shall have a removable top cover, which shall be flush with finished ground level. The enclosure shall be a purpose made inspection pit made of concrete, galvanised steel or plastic material embedded in concrete, as indicated. The earth electrode connection shall be just below the lid of the inspection pit with adequate access for testing purposes. The enclosure shall be clearly labelled to indicate the electrodes function and, where appropriate, its identification number.

11.6 SUPPORTS AND FIXINGS

11.6.1 Cables shall be supported and fixed in accordance with Section 5.

11.6.2 Tapes and bars shall be fixed by spacer bar saddles which shall be of non-metallic material or corrosion resistant alloy, compatible with the conductors maximum temperature under fault condition. Fixing of the saddles shall comply with Table 8A. The maximum spacing of fixings shall not exceed 600mm unless otherwise indicated.

11.6.3 Main earthing bars shall be supported on insulators suitable for the maximum temperature under fault condition. They shall be not less than 50mm clear of the building fabric.

11.6.4 For general areas inside buildings, screws and nuts shall be non-corrosive and compatible with the environment; outside buildings, in plant rooms or other locations as indicated they shall be stainless steel.

11.6.5 No shot firing shall be used and no drilling or welding of structural steelwork shall be done without the approval of the Project Manager.

11.7 INSTALLATION

11.7.1 Electrodes shall be installed in undisturbed ground. The distance between any two electrodes shall be not less than the sum of the lengths of the two electrodes.

11.7.2 Excavations and backfilling shall comply with clause 6.4 as appropriate. Backfill immediately surrounding plate electrodes shall have a low specific resistivity and good water retention properties, and shall be well compacted.

11.7.3 Electrode seals shall be provided where earth rods are to be installed through the base slab of a building. As indicated, either: the rods shall be driven and the seals fitted before the concrete is poured; or the seals shall be handed to the Building Contractor for him to incorporate into the slab for the rods to be driven at a later date. Ingress of water shall be avoided when driving the rods.

11.7.4 Earth plates shall be installed vertically in an excavated hole, with the top of the plate at a minimum depth of 1m below finished ground level. Where difficulty in achieving this depth is met the Project Manager shall be consulted.

11.7.5 Installation of conductors shall comply with Section 6 as appropriate.

11.8 BONDING TO INCOMING SERVICES

11.8.1 Bonding to incoming services shall be to BS 7671.

11.8.2 Where a service belongs to a Supply Company, the permission of the Supply Company shall be obtained before connection is made.

Section Twelve – Wiring Accessories and Small Equipment

12.1 ACCESSORIES - GENERAL

12.1.1 Accessory boxes used with steel conduit and with mineral insulated cables shall be metal and those used with multi-cored sheathed cables installed in accordance with Section 9 shall be of insulating material, unless otherwise indicated.

12.1.2 Accessory boxes of insulating material shall have the ignitability characteristic "P" as specified in BS 476.

12.1.3 Accessory boxes shall be suitable for flush or surface mounting, as indicated. Metal boxes for general use inside buildings shall be of steel with medium category of protection against corrosion; for use in plant rooms and outside buildings and other locations as indicated they shall be steel with heavy category of protection.

12.1.4 Accessory boxes shall be of adequate depth to accommodate the accessories without causing compression of the cables. Generally boxes shall be 35mm deep, but for lighting switches installed flush in plaster finish with multi-cored sheathed cables complying with Section 9, 16mm depth boxes may be used.

12.1.5 Earthing terminals shall be fixed inside each accessory box and on the grids of gridswitches. The earthing terminal of each grid shall be connected by a separate protective conductor to the earthing terminal of the box.

12.1.6 Front plates of accessories shall be of the material and finish as indicated, but generally the finish of various types of accessories in the same area shall match. For flush mounting the plates shall overlap the boxes, and for surface mounting the plate shall match the profile of the box without overlap.

12.1.7 Where pilot lamps are required they shall comprise a neon lamp with resistor and a red coloured lens integral with the accessory, unless otherwise indicated. Pilot lamps shall be wired to show supply status or load status as indicated.

12.1.8 Accessories with their boxes and front plates shall provide a minimum degree of protection of IP41 when used inside buildings and IP44 when used outside buildings or at other locations, unless otherwise indicated.

12.1.9 Accessory boxes shall be fixed to the fabric of the building independently of the connecting cable or conduit, and as specified for conduit boxes in Table 8A. Where the accessories have a minimum degree of protection of IP44 the fixings shall not reduce that protection.

12.2 SWITCHES

12.2.1 Switches shall comply with the relevant British Standard for the type of switch indicated.

12.2.2 Switches shall be single pole for single-phase circuits and three pole for three phase circuits, unless otherwise indicated. Their current ratings shall be as indicated. Lighting switches in fluorescent or discharge lamp circuits shall be rated for 20A inductive loads unless otherwise indicated.

12.2.3 Wall mounted switches located inside buildings shall have rocker type actuating members. Where mounted adjacent to one another they shall be grouped in a multi-gang box with a common front plate or in a gridswitch.

12.2.4 Pull cord operated switches installed in conduit systems shall be fixed to white moulded plastic mounting blocks which in turn shall be fixed to a circular conduit box. Where the conduit boxes are flush with the finish the mounting block shall overlap them.

12.3 DIMMERS

12.3.1 Dimmers for the control of tungsten filament lamps shall comply with BS 5518. For other dimmers the limits and the methods of measurement of radio-frequency interference generated by the electronic assembly shall be in accordance with BS EN 55015.

12.4 SOCKET OUTLETS

12.4.1 Socket outlets shall comply with the relevant British Standard for the type of outlet indicated.

12.4.2 Socket outlets shall be of the type and rating as indicated. Pilot contacts shall be provided where indicated.

12.4.3 Socket outlets shall be switched where indicated. On socket outlets rated at 13A and located inside buildings the switches shall be single pole and have rocker type actuating members unless otherwise indicated.

12.5 SOCKET OUTLETS FOR WET LOCATIONS

12.5.1 Socket outlets shall be provided with covers. Any cover required to achieve total enclosure and to ensure the required degree of protection against moisture shall be securely fixed to the socket outlet.

12.6 PLUGS

12.6.1 Plugs shall be provided as indicated. Plug bodies shall be of metal, plastic or other material as indicated.

12.6.2 Plugs rated at 13A shall be of a non-resilient material unless otherwise indicated.

12.6.3 Fused plugs shall be fitted with fuses rated as indicated.

12.7 SHAVER SOCKET OUTLETS

12.7.1 Shaver socket outlets shall be to BS 4573.

12.8 FUSED CONNECTION UNITS

12.8.1 Fused connection units shall be double pole switched and fitted with pilot lamps where indicated. Fuses shall be rated as indicated.

12.8.2 Front plates shall incorporate a flex outlet with a clamp for anchoring the flexible cord, where indicated.

12.9 COOKER CONTROL UNITS

12.9.1 Cooker control units shall comply with BS 4177 and, unless otherwise indicated, shall be rated at 45A and have a 13A switched socket outlet with pilot lights for both functions.

12.10 TELEPHONE CORD-OUTLETS

12.10.1 Telephone cord-outlets shall be of the type indicated.

12.11 SAFETY ISOLATING TRANSFORMERS

12.11.1 Safety isolating transformers shall be fixed type and their enclosures shall provide a minimum degree of protection of IP44. The nominal rated input voltage shall be 230 volts and tappings shall be provided on the input winding for alternative input voltages. The output windings shall be centre tapped and the tapping connected to earth.

12.11.2 Cartridge fuses or MCB's shall be provided to protect the input winding and both poles of each outgoing circuit.

12.11.3 Transformers supplying only hand lamps and bench lamps shall comply with Section E of BS 3535 and shall have an output voltage of 50 volts and a rated output of 100VA. One socket outlet shall be mounted on the transformer enclosure and terminals shall be provided within the enclosure for two other outgoing circuits.

12.11.4 Transformers supplying portable tools or other equipment shall comply with Section D of BS 3535 and shall have dual secondary windings with rated outputs of 400VA at 110 volts and 100VA at 50 volts. Two socket outlets shall be mounted on the transformer enclosure, one for each voltage. In addition, terminals shall be provided within the enclosure for two other outgoing circuits for each voltage.

12.11.5 Socket outlets for 50 volt circuits shall be rated at 5A and for 110 volt circuits they shall be rated at 16A, and shall be to BS EN 60309-2.

12.11.6 A separate terminal shall be provided for each outgoing conductor and bunching of conductors in one terminal will not be accepted. Conduit entries shall be provided for input and output cables.

12.11.7 Transformers for bell or alarm circuits shall comply with Section B or C of BS 3535, as appropriate, and shall be suitably rated for the connected load.

12.12 ROOM THERMOSTATS

12.12.1 Room thermostats shall comply with BS 3955 and BS EN 60730 or BS EN 61058. Switches shall be single pole, single throw, and rated as indicated. The rated current shall be as indicated.

12.12.2 Thermostats shall be adjustable and shall have a visible indicator and a calibrated temperature scale. Adjustment shall not require a special tool and fixed covers shall be provided to prevent tampering by unauthorised persons.

12.12.3 No provision for manual overriding of the thermal switching shall be included, unless otherwise indicated.

12.12.4 Thermostats shall be suitable for mounting direct on to a circular conduit box or adaptable box.

12.13 ELECTRICITY METERS

12.13.1 Electricity meters shall be of the direct connection type complying with the appropriate part of BS 5685, BS EN 61036 unless otherwise indicated.

12.13.2 Maximum demand meters shall comply with BS 5685 and shall be of the whole current type unless otherwise indicated.

12.13.3 Meter boards, where required, shall be of 20mm thick wood chipboard complying with BS 5669, Type I.

12.14 TIME SWITCHES

12.14.1 Unless otherwise indicated, time switches shall be battery backed electronic or self-starting, self-winding, synchronous motor type rated as indicated. The motor shall be protected by a fuse which shall be easily accessible. The rated current of the switch shall be as indicated.

12.14.2 Time switches shall be of the demountable type.

12.15 PHOTO-ELECTRIC CONTROL UNITS

12.15.1 The sensing unit shall comprise a photo-conductive cell enclosed in a translucent plastic dome sealed to a mounting base and have number of poles and rated current as indicated.

12.16 BELLS AND BUZZERS

12.16.1 Bells and buzzers shall have contactless movements and shall not incorporate a transformer.

12.16.2 Bell gongs shall have a minimum diameter of 75mm unless otherwise indicated.

12.16.3 Bells mounted outside a building shall provide a minimum degree of protection of IP54 and shall have a tapped entry for steel conduit.

12.16.4 The base and cover of buzzers shall be of plastic material.

12.17 PUSHES

12.17.1 Pushes shall have a current rating of 1A unless otherwise indicated and shall be suitable for flush or surface mounting as indicated. Voltage rating shall be as indicated.

12.17.2 Boxes and front plates shall comply generally with clause 12.1.

12.18 INDICATORS

12.18.1 Indicator units for alarm or call systems shall incorporate the number of signals as indicated.

12.18.2 Enclosures shall be as indicated.

12.18.3 Inscriptions shall be as indicated.

12.19 TERMINAL BLOCKS

12.19.1 Terminal blocks shall comprise connectors contained within a moulded housing complying with BS EN 60998.

12.19.2 Conductors shall be clamped between metal surfaces and no screws shall make direct contact with conductors. The design shall be such as to maintain sufficient contact pressure to ensure connections of negligible impedance at all times.

12.19.3 Metal in contact with conductors shall be compatible with the conductors. The moulded housing shall be of an insulating material suitable for the maximum operating temperature of the conductors.

12.20 MOUNTING HEIGHTS

12.20.1 Mounting heights shall be in accordance with Table 12A unless otherwise indicated.

12.20.2 Where difficulty in locating accessories or equipment occurs, the Project Manager shall be consulted

TABLE 12A MOUNTING HEIGHTS (for accessories and equipment)

Accessories or Equipment	Location of Function	Height mm
Lighting switch	Location:	
	general	1350
	disabled toilet	1000
Shaver socket outlet		1350
Socket outlet	Location:	
	General	200
	Kitchens	1350
	homes for disabled or elderly	1000
	above worktops	200
	external	1350
	car parks and garages	See Note 4
Data outlet point	General	200
		1350
Fused connection unit	Controlling:	
	radiant heater - wall	1800)
	radiant heater - focal point	200) See also
	tubular heater	200) Clause
	clock	1900) 13.1.2
		)
	Location:	)
	above worktop	200)
Cooker control unit		1350
Cooker connection outlet		600
Room thermostat		1600
Telephone outlet		200
Radio/TV outlet		200
Push-button		1350
Fire alarm manual call point		1350
Bell, buzzer or sounder		1900
Key switches		1350

NOTES:

1. Heights are from finished floor level to the centre of the accessory or equipment, except in the case of worktops when the measurement shall be from the worktop surface.

2. If the specified height of an accessory coincides with the top of tiling, the accessory shall be mounted above the tiling, leaving a clear gap of 50mm.

3. Where apparatus is located underneath a worktop the accessory shall be mounted 100mm below the underside of the worktop.

4. In car parks and garages the heights shall comply with appropriate regulations relating to the presence of petroleum vapour.

Section Thirteen – Connections to Appliances and Motors

13.1 GENERAL

13.1.1 The following clauses and Table 13A specify standard connection methods for a range of appliances and motors and these methods shall be used unless otherwise indicated. For connections to luminaires refer to Section 14.

13.1.2 Switches or fused connectors shall be located 150mm from appliances except where otherwise stated in the following clauses or otherwise indicated.

13.1.3 A protective conductor shall connect the earthing terminal of each appliance or motor to an earthing terminal incorporated in the adjacent switch or connector box.

13.2 FLEXIBLE CORDS

13.2.1 Flexible cords shall be as Table 13A unless otherwise indicated.

13.2.2 Flexible cords shall include a protective conductor except where used in a non-conducting location, and for connection to Class II or Class III equipment as defined in BS 7671, unless otherwise indicated.

13.2.3 For connection to appliances which may require to be moved for maintenance or cleaning, the flexible cord shall be 1.5m long.

13.3 WATER HEATERS

13.3.1 The cable from the switch or fused connector shall be connected directly to the terminals on the heater.

13.3.2 The location of the switch or fused connector shall be as indicated.

13.3.3 For instantaneous water heaters mounted in bathrooms and kitchens, the conduit shall be concealed in the building fabric and terminated at the heater in a circular conduit box flush with the wall finish. Where possible the connection shall enter through the back of the heater.

13.4 ROOM HEATERS

13.4.1 Where a room thermostat controls a heater, the switch or fused connector shall be mounted in a deep box incorporating a terminal block to enable the cables to the thermostat to be connected. The terminal block shall comply with clause 12.19.

13.4.2 The location of the fused connector for radiant heaters in bathrooms shall be as indicated.

13.5 TOWEL RAILS

13.5.1 For wall mounted towel rails intended for connection to the permanent wiring the concealed wiring shall terminate in a circular conduit box located immediately adjacent to the conduit entry of the towel rail. A dome lid shall be fitted to the conduit box and be connected to the heater by steel conduit, and both shall have Class 4 protection.

13.5.2 For floor mounted towel rails the steel conduit shall rise from the floor and connect to the heater directly. The cables from the switch or fused connection unit shall be connected directly to the terminals on the towel rail.

13.5.3 The location of the switch or fused connector shall be as indicated.

13.6 COOKERS

13.6.1 The final circuit wiring shall be concealed in the building fabric and connect from the cooker control unit to a cooker connection outlet located immediately behind the appliance.

13.7 WASTE DISPOSAL UNITS (DOMESTIC)

13.7.1 The fused connection unit shall be located adjacent to the sink, and connected to a flex outlet under the sink as near as possible to the waste disposal unit via conduit concealed in the building fabric, unless otherwise indicated.

13.8 SANITARY DISPOSAL UNITS

13.8.1 Units shall be connected from the fused connection unit to the unit via conduit concealed in the building fabric, unless otherwise indicated.

13.9 EXTRACT FANS

13.9.1 The connections to small single-phase fans shall be as indicated in Table 13A.

13.9.2 Connections to larger fans shall be as indicated.

13.10 OTHER APPLIANCES

13.10.1 For appliances not covered in the foregoing, connections shall follow similar methods unless otherwise indicated.

13.11 PLANT, MACHINERY AND MOTORS

13.11.1 Connections shall allow for vibration and adjustment of the motor on its slide rails.

13.11.2 Final connections shall be as indicated.

13.11.3 Final connections to small single-phase items in domestic situations shall be via sheathed flexible cords.

TABLE 13A CONNECTIONS TO APPLIANCES

Appliance	Maximum Rating	Outlet		Rating of Fuse (BS 1362) A	Cable or Cord		Comment
		Type	Pilot Lamp		Type	Size mm²	
Water Heater							
- storage	1kW	SFC	yes	13	D	1.5	See clause 13.3.1
	3kW	DPS	yes	-	D	2.5	& note 1
- instantaneous	1kW	SFC	yes	13	E	1.5	See clause 13.3.3
	3kW	DPS	yes	-	E	2.5	& note 1
Room Heater							
- storage	3kW	DPS	yes	-	D	2.5	See clause 13.4.1
- tubular	0.5KW	SFC	Yes	5	D	1.0	See clause 13.4.1
	1kW	SFC	yes	13	D	1.5	
	3kW	DPS		-	D	2.5	
- radiant	2kW	SFC	no	13	D	2.5	See clause 13.4.2
Towel Rail	-	SFC	yes	13	E	1.5	See note 13.5
Cooker	32A	CC or DPS	yes	-	D		See clause 13.6
	45A	CC	yes	-	D		
Waste Disposal Unit (domestic)	-	SFC and FO	yes	13	A	1.5	See clause 13.7
		DPS	no	-	A or C	1.0	
Sanitary disposal Unit					A		See clause 13.8
- macerator	-	SFC	yes	13		1.5	
- incinerator	-	SFC	yes	13	E	1.0	
Extract fan (single phase) Wall or window mounted		SFC	yes	3	B	1.0	See clause 13.9 See note 2
-without controller	150W	SFC withFO or DPS	yes	3	A or C	1.0	
			no	-	B	1.0	See notes 3 and 4
- with unfused controller	150W	SFC with FO or DPS	no	3	A or C	1.0	See note 5
			no	-	B	1.0	See notes 3 and 4
- with fused controller	150W	SFC with FO or DPS	no	13	A or C	1.5	See note 5
			no	-	B	1.0	See notes 3 and 4

CODINGS - outlets: DPS = 20A double pole switch: SFC = 13A switched fused connector (see clause 12.10)
CCO = cooker connection outlet; FO = flex outlet.

- cables: A = Thermoplastic (PVC/LSF) insulated, non sheathed cables in conduit (as Section 8)
B = Thermoplastic (PVC/LSF) insulated and sheathed (circular) flexible cord
C = Thermoplastic (PVC/LSF) insulated multi-core sheathed cables (as Section 9)
D = 85°C thermosetting (rubber) insulated HOFR sheathed flexible cord
E = 85°C thermosetting (rubber) insulated non-sheathed cables in conduit (as Section 8)

For other applications refer to Table 3B of the IEE Onsite Guide 2002

NOTES:
1. SFC or DPS to be engraved with the legend "WATER HEATER".
2. Applies only when SFC immediately adjacent to fan.
3. Where fan is in the same room as and not more than 2m from SFC, an FO to be located immediately adjacent to the fan.
4. Where fan is more than 2m from SFC, a DPS to be located immediately adjacent to fan.
5. Cable to be routed from SFC via controller to FO or DPS.

Section Fourteen – Luminaires and Lamps

14.1 LUMINAIRES

14.1.1 Luminaires shall comply with BS 4533, BS EN 60598 and with this Section.

14.1.2 Emergency lighting luminaires shall comply also with Industry Standards ICEL 1001, 1004, 1006, 1008, 1009 and shall be marked with the ICEL certification label. Self-contained emergency lighting luminaires shall be fitted with a means of testing at locations indicated. They shall be provided with a means of isolating the lamp circuit for maintenance purposes. (Special provisions may apply for "self testing" emergency lighting systems).

14.1.3 Unless otherwise indicated, fixed luminaires shall be Class I, and hand lamps shall be Class III rated at 50 volts.

14.1.4 Unless otherwise indicated, enclosures of luminaires shall provide a minimum degree of protection of IP2X when located within buildings and IP44 when located outside buildings.

14.1.5 Luminaires, both with and without built-in control gear, shall be "F" marked if mounted on flammable surfaces.

14.1.6 Where specific requirements related to flame propagation and flammability of translucent covers are indicated, certificates of tests carried out on samples of the material shall be submitted to the Project Manager. The tests shall comply with BS 2782.

14.1.7 Terminal blocks for connection of the supply cables shall be adequate for the size of conductors forming the loop-in wiring specified in clauses 8.12.2 and 9.4.9, unless separate tails are required as in clause 14.8. Terminal blocks shall incorporate a fuse of suitable type and rating unless otherwise indicated.

14.1.8 Inductive ballasts for fluorescent lamps shall comply with BS EN 60920 and BS EN 60921. Electronic ballasts for tubular fluorescent lamps shall comply with BS EN 60928 and BS EN 60929. Ballasts for discharge lamps shall comply with BS EN 60922 and BS EN 60923. Power factor correction shall be provided and this shall be to not less than 0.85 lagging.

14.1.9 Translucent covers and reflective surfaces shall be clean at the completion of the Works.

14.2 STREET LIGHTING COLUMNS

14.2.1 Street lighting columns shall be constructed and installed in accordance with BS 5649 and BS EN 40 and shall be of the type as indicated. Columns set in ground shall be fitted with a base plate unless otherwise indicated.

14.2.2 Each column shall be fitted with a fuse unit providing terminations adequate for the cabling to be looped in and out and shall be fitted with fuses to BS 88 or MCB, as indicated. Control equipment shall be incorporated as indicated.

14.3 LAMPS

14.3.1 Lamps shall be of the type and rating as indicated.

14.3.2 All lamps shall be supplied and installed by the Contractor unless otherwise indicated.

14.3.3 Tungsten GLS lamps shall be suitable for the lamp holders listed in Table 14A.

14.4 LAMPHOLDERS

14.4.1 General lighting service (GLS) lampholders shall comply with Table 14A. Other lampholders shall be suitable for the lamps specified.

14.4.2 Bayonet lampholders in enclosed luminaires shall have the temperature rating T2, as described in BS EN 61184.

14.4.3 Lampholders for use with flexible cords shall be of the cord-grip type.

14.4.4 Lampholders not in a luminaire shall have a shade carrier ring.

14.5 CEILING ROSES

14.5.1 Ceiling roses shall be of insulating

material having the ignitability characteristic "P" as specified in BS 476. Extension flanges shall be fitted to all surface mounted ceiling roses where the wiring installation is concealed in the building fabric. Luminaire supporting couplers shall comply with BS 6972.

14.5.2 Where plug-in connections are indicated suitable proprietary socket outlets and plugs shall be provided for mounting onto a circular conduit box or other arrangement as indicated.

14.6 PENDANTS AND CHAIN SUSPENSIONS

14.6.1 Luminaires shall be suspended at the height indicated.

14.6.2 A plain pendant shall include a ceiling rose, flexible cord and lampholder. The flexible cord shall be three core 1.0mm^2, 85°C heat resisting Thermoplastic (PVC) insulated and the sheath shall be white, unless otherwise indicated.

14.6.3 A tube pendant shall comprise a ball and socket cover to fit a circular conduit box, and steel conduit not less than 20mm diameter. At the conduit entry to the luminaire a backnut shall be used. Complete pendant assemblies shall be protected against corrosion in accordance with clause 8.3.2, except where specific finishes are indicated.

14.6.4 A chain suspension shall comprise a hook cover fixed to a circular conduit box and a chain, having a load carrying capacity not less than twice the weight of the luminaire.

14.7 SUPPORTS AND FIXINGS

14.7.1 Where fluorescent luminaires 1200mm or more in length are supported directly by the conduit system they shall be fixed to two circular conduit boxes, both of which shall form an integral part of the conduit system.

14.7.2 Where the weight of a luminaire is supported by a conduit box or cable trunking the fixing of the conduit box or trunking shall be adequate for the purpose.

14.7.3 Luminaires fitted with tungsten filament lamps and having metal backplates shall not be fixed directly to a conduit box in which a thermoplastic material is a load-bearing member.

14.7.4 Support of luminaires from cable trunking shall be by means of proprietary clamps or brackets.

14.7.5 Where luminaires are supported from the structure other than by the conduit system the supports shall comply with clause 5.7. Where luminaires are fixed direct to the structure the fixings shall be as specified in Part 2 of Table 8A.

14.7.6 Luminaires mounted on, or recessed into, suspended ceilings shall be supported independently of the ceiling system unless otherwise indicated.

14.7.7 For wall mounted luminaires the mounting height shall be 1900mm above finished floor level, measured to the centre of the conduit box, unless otherwise indicated.

14.8 WIRING CONNECTIONS

14.8.1 Where luminaires, other than those covered by clause 14.8.2, are fixed direct to circular conduit boxes or are supported by pendants or chains, the final circuit wiring shall terminate at a terminal block in the conduit box.

14.8.2 Where luminaires having fluorescent tubes are fixed direct to circular conduit boxes, the final circuit wiring may be terminated within the luminaire unless otherwise indicated. The wiring shall enter each luminaire at the conduit entry nearest to the terminal block and, where a loop-in wiring system is used, leave by the same entry. Wiring shall not pass through a luminaire unless the approval of the Project Manager is given.

14.8.3 Where luminaires are mounted on, or recessed into, a suspended ceiling, connection shall be by flexible cord from a plug-in ceiling rose unless otherwise indicated. The plug-in ceiling rose shall be located not more than 500mm from the access in the ceiling and shall be firmly supported.

14.8.4 Cables and flexible cords for final connections to luminaires shall be suitable for the operating temperature of the luminaire. Flexible cords for chain suspensions shall have a white sheath unless otherwise indicated, and for plain pendants they shall comply with clause 14.6.2.

14.8.5 The size of final connection cables or flexible cords shall be as indicated.

14.8.6 Where mineral-insulated cable is used the requirements of clause 10.2.2 shall be met.

14.8.7 Cables and cords passing close to a ballast within a luminaire shall be suitable for the operating temperature of the ballast.

14.8.8 Terminal blocks, other than those forming part of the luminaires, shall comply with clause

12.19 and the requirements of clause 8.10.6 shall be met.

14.8.9 A protective conductor shall connect the earthing terminal or earthing contact of each luminaire to an earthing terminal incorporated in the adjacent conduit box. Where the final connection is by flexible cord the protective conductor shall form part of the cord.

TABLE 14A LAMPHOLDERS

Lamp type	Rating (watts)	Lampholders
Tungsten filament	up to 150W	Bayonet B22d
	200W	Edison screw E27
	300W and above	Edison screw E40

Section Fifteen – Emergency Lighting

15.1 GENERAL

15.1.1 Emergency lighting systems and equipment shall comply with BS 5266 and ICEL 1001, 1004, 1006, 1008, 1009 and other relevant standards, and also Section 14.

15.2 CENTRAL BATTERIES

15.2.1 Batteries shall be as indicated and shall comply with the relevant British Standard.

15.2.2 Batteries shall be contained as indicated. Enclosures shall comply with clause 2.2. Insulating covers shall be provided over all cell terminals and inter-connections. All leads shall be insulated.

15.2.3 Batteries shall be maintained in good condition on site with all necessary precautions being taken to prevent deterioration. They shall be handed over fully charged at the completion of the Works.

15.2.4 All necessary equipment for routine maintenance as recommended by the Manufacturers shall be provided with each group of batteries.

15.3 CENTRAL BATTERY CONTROL EQUIPMENT

15.3.1 All the control equipment including mains failure relays, contactors, battery charger, inverter (where required), protection fuses, control switches, instruments and indicators shall be contained in enclosures complying with clause 2.2. All equipment shall be suitable for, and optimised to suit, the batteries provided.

15.3.2 Battery chargers shall be capable of recharging the batteries after they have been discharged for the specified duration of the system so that within 14 hours, or other period where indicated, the batteries can again support the load for the specified duration period. This requirement shall be achieved without exceeding the maximum design charging characteristics of the batteries.

15.3.3 Instruments shall provide indication of battery voltage, trickle charge and boost charge currents. Indication shall be provided of battery charger functioning and battery charger failure. Other instruments and alarms and provision for remote display of alarms shall be provided as indicated.

15.3.4 Simulation of mains failure shall be by means of a tamper-proof switch operated by a removable key unless otherwise indicated.

15.4 WIRING

15.4.1 The wiring installation shall comply with the relevant Sections of this specification. The type and size of cables shall be as indicated.

15.4.2 Wiring shall not be drawn into the same conduit, trunking compartment or ducting compartment as cables of other Band I circuits. The cores of emergency lighting circuits shall not be contained within the same multicore cable, flexible cable or flexible cord as cores of any other circuits.

Section Sixteen – Potentially Explosive Atmospheres

16.1 STANDARDS AND CODES OF PRACTICE

16.1.1 Equipment and installation in potentially explosive atmospheres shall comply with other Sections of this Specification as applicable and the requirements of the Dangerous Substances and Explosive Areas Regulations.

16.1.2 Equipment shall comply with BS 4683, relevant parts of BS 4999, BS 5000 and BS 5501, BS 6941, BS EN 50281, BS EN 50014-50020 and 60079, and other standards as indicated. Equipment shall be certified by BASEEFA or, with the approval of the Project Manager, by an equivalent testing authority. Copies of certificates and Manufacturers instructions shall be submitted to the Project Manager.

16.1.3 Installations shall comply with BS EN 60079, BS 7535 and with other codes and standards as indicated.

16.1.4 The zonal classification, temperature classification, apparatus group and type of protection shall be as indicated.

16.2 MINISTRY OF DEFENCE MILITARY EXPLOSIVES AREAS

16.2.1 Equipment and installations, including lightning protection, in MOD military explosives areas shall comply with specific regulations issued by the MOD or armed services. Information pertaining to these areas shall be sought from the Project Manager.

Section Seventeen – Lightning Protection of Buildings

17.1 GENERAL

17.1.1 The installation shall comply with BS 6651 and BS 7430.

17.2 AIR TERMINATIONS

17.2.1 The type and location of air terminations shall be as indicated.

17.2.2 Metal framed or metal clad roofs or metal copings which form part, or all, of an air termination shall be bonded across joints between constituent parts. The bonding may be carried out by the specialist roofing Contractor but where this is not the case the bonds shall be made as indicated. No drilling of roofing or coping shall be done without the approval of the Project Manager.

17.2.3 Roof fixings shall not affect the integrity of the roofing and shall be as indicated.

17.3 DOWN CONDUCTORS

17.3.1 The type and location of down conductors shall be as indicated. No aluminium conductor shall be buried in the ground.

17.3.2 Conductors connecting between a test clamp on the outside of a building and an earth electrode shall be sheathed; but conductors interconnecting copper electrodes may be left bare. Conductors in other locations shall be sheathed where indicated. Sheaths shall be of Thermoplastic (PVC), extruded, shrunk-on or similarly applied and the colour shall be as indicated.

17.3.3 The Project Manager shall be consulted where the profile of the building would cause an overhang or re-entrant loop to be formed in a down conductor.

17.3.4 Metalwork, including metal windows, handrails, pipework, ductwork and cables, adjacent to down conductors shall be bonded to them unless the distance between them provides adequate isolation. The distance necessary to provide adequate isolation shall be as described in BS 6651 unless otherwise indicated.

17.3.5 Where the reinforcement of a concrete structure forms the down conductors, exposure of connection points to the reinforcement will be carried out by the Building Contractor. The Lighting Protection Contractor shall make the connections and carry out testing as described in clause 19.8.1 unless otherwise indicated.

17.3.6 Connections to earth electrodes from down conductors formed by reinforcing steel or concrete clad steel frames will be made by the Contractor. They will comprise copper tape, not less than 20mm x 3mm, welded onto the steelwork or bolted to a welded bracket.

17.4 JOINTS

17.4.1 Joints in conductors shall be kept to a minimum.

17.4.2 Joints between conductors of the same metal, other than at test points, shall be made by an exothermic welding process. Overlap of conductors shall be not less than 100mm.

17.4.3 Where an aluminium conductor is joined to a copper conductor, one of the following methods shall be used:
a bi-metal connector formed by friction welding of high purity copper and aluminium;
the copper conductor shall be completely sheathed for at least 100mm of its length with metal strip electrolytically compatible with copper and aluminium, and then clamped to the aluminium conductor.

Bi-metal joints shall not be made at test points nor between the test point and earth electrode.

17.4.4 A test clamp shall be provided in each down conductor except where the earth electrode is the structure below ground. It shall be located 1m above ground level unless otherwise indicated. Test clamps shall be of cast material appropriate to the conductor material.

17.4.5 Bonding connections to other metal parts of the building shall be electrolytically compatible with those metal parts.

17.4.6 Screws shall be of the following materials:

for copper conductors: phosphor bronze, naval brass or high-tensile manganese brass;

for aluminium conductors: stainless steel.

17.4.7 Joints shall be protected as specified in clause 11.4.6.

17.5 EARTH ELECTRODES

17.5.1 Earth electrodes other than the building structure below ground shall comply with clause 11.2 and shall be installed in accordance with clause 11.7.

17.5.2 Inspection pits shall be provided in accordance with clause 11.5.

17.6 FIXINGS

17.6.1 Fixings shall be in accordance with Table 17A, but the Project Manager's approval of the type of clips, saddles and holdfasts to be used shall be obtained before work is started. The maximum spacings of fixings shall not exceed 900mm. No fixings shall be made into joints in masonry.

17.6.2 Saddles and holdfasts shall be of the following materials:

for copper conductors: gunmetal, phosphor bronze or naval brass;

for aluminium conductors: aluminium, aluminium alloy or stainless steel.

Clips shall be either of metal, as above, or of outdoor grade polycarbonate or polypropylene with snap-on lids which cannot be inadvertently removed. Clips and saddles shall have rounded edges and countersunk screws. Brass components shall not be used.

17.6.3 For general areas inside buildings, screws and nuts shall be non-corrosive and compatible with the environment; outside buildings, in plant rooms or other locations as indicated, they shall be of stainless steel.

17.6.4 No shot firing shall be used and no drilling or welding of structural steelwork shall be done without the approval of the Project Manager. Drilling and cutting of the outside fabric of the building shall be carried out only after the Project Manager has given approval.

TABLE 17A CONDUCTOR FIXINGS (lightning protection)

Building Fabric	Type of Fixing
1. Outside Buildings:	
Masonry and concrete	Clips or spacer saddles with nylon or plastic plugs and screws; holdfast caulked-in; backplate holdfasts; inserts built-in to new concrete.
Asphalt	Asphalt pads; purpose made backplate holdfasts.
Metal roofs and copings	As indicated.
Sloping roofs	Corrugated holdfasts or slate holdfasts, as appropriate; other fixings compatible with the materials and the environment.
Other roofs	As approved by the Project Manager.
2. Inside Buildings:	
All types of fabric	as Table 8A.

Section Eighteen – Cathodic Protection

18.1 GENERAL

18.1.1 Cathodic protection shall comply with BS 7361 and shall be by impressed current unless otherwise indicated.

18.1.2 Information on the nature of the soil, whether it is aerobic or non-aerobic and if so whether it contains sulphate reducing bacteria, may be indicated in the tender documents. If it is not indicated, the Contractor shall analyse samples of soil taken at various locations across the area to be protected, ensuring that samples are taken from areas of imported backfill as well as from undisturbed ground. Total current demand for the installation shall be based on the sample having the lowest resistivity.

18.2 GROUNDBEDS

18.2.1 Groundbeds shall be located within the areas indicated.

18.2.2 Anodes shall be of silicon iron chrome unless otherwise indicated. Each anode shall be fitted with a cable tail comprising a single-core polythene-insulated Thermoplastic (PVC) sheathed cable not less than 10mm. The connection to the anode shall be mechanically and electrically sound and shall be sealed against ingress of moisture. Details of the proposed method of connection shall be submitted for the approval of the Project Manager.

18.2.3 The number and size of anodes in each groundbed shall be adequate to sustain the required current for not less than 20 years, or other period where indicated. The Contractor shall provide to the Project Manager calculations to demonstrate that this requirement will be met.

18.2.4 Each anode shall be buried so that the top is not less than 1.5m below ground level and surrounded by not less than 300mm of backfill.

18.2.5 Where the soil resistivity is less than 1000 ohm.cm the backfill shall be soil which has passed through a sieve with a maximum mesh of 12mm. The soil shall be tamped around the anodes and to a depth of 300mm above them.

18.2.6 Where the soil resistivity is greater than 1000 ohm.cm the backfill shall be coke breeze which has passed through a sieve with a maximum mesh of 12mm. The resistivity of the coke breeze shall not exceed 50 ohm.cm before any additive is made to it. The coke breeze shall be thoroughly mixed with 5% to 10% by weight of slaked lime. Alternative materials shall only be used with the permission of the Project Manager.

18.3 SOURCE OF POWER

18.3.1 The transformer and rectifier units shall be supplied by a Manufacturer with proven experience in making equipment for cathodic protection. They shall be suitable for the full current range to be expected during the life of the installation.

18.3.2 The equipment shall conform with the requirements of all relevant standards and this Specification.

18.3.3 Provision shall be included to enable the protection current to be adjusted by control of the rectifier output and, where there are multipole anode or cathode circuits, individually in each circuit.

18.3.4 Each transformer and rectifier unit shall include a means to indicate the direct current (dc) output voltage and the total output current. Where more than one anode or cathode circuit is supplied from the same unit the means to identify the current in each circuit shall be provided. A mains supply "ON" indicator lamp shall be provided.

18.4 CABLING

18.4.1 Cables to anodes and cathodes shall have copper conductors with Thermosetting (Ethylene or Chlorosulphonated Polyethylene Rubber) insulation and Thermoplastic (PVC) sheaths, with or without armouring as indicated.

18.4.2 Cables shall be sized so that the total voltage drop in a circuit will not exceed 20% of the

rectifier output voltage when the maximum current anticipated in the life of the installation flows.

18.4.3 Cables shall be installed in accordance with the requirements of Section 6.

18.4.4 Jointing and terminating cables shall comply with clause 3.7 except that where armouring is included it need not be bonded.

18.4.5 Cable connections to cathodes shall be protected with a material compatible with the protective coating of the cathode.

18.5 TEST POINTS AND BONDING

18.5.1 Test points shall be fixed to buried structure or pipes where indicated. They shall be fixed by welding, preferably by an exothermic process. The Project Manager shall approve the proposed method of fixing before work commences.

18.5.2 Test points shall be connected by Thermoplastic (PVC) insulated cable to terminations within inspection pits similar to those specified in clause 11.5, or on posts, as indicated. Where a number of test points are adjacent to each other they shall be terminated in a common inspection pit.

18.5.3 Where the tests specified in clause 19.13.2 show bonding across joints in pipework or structure to be necessary, each bond shall be made by a copper tape or cable connected directly to the flanges by an exothermic welding process. The whole of the bond shall be protected in accordance with clause 18.4.5.

18.6 MARKING

18.6.1 Marking of cables shall comply with clause 6.11. In addition markers complying with that clause shall be placed above each anode inscribed "CATHODIC PROTECTION GROUNDBED". The joint to the cable tail from the anode need not be additionally marked. Test point inspection pits or posts shall be inscribed "CATHODIC PROTECTION TEST POINT".

Section Nineteen – Inspection and Testing

19.1 GENERAL

19.1.1 Inspection and testing shall be done in accordance with BS 7671, the associated IEE Guidance Notes, and the requirements of this Section.

19.1.2 Inspection shall include a physical check that all equipment has been securely fixed and that all electrical connections are mechanically sound.

19.1.3 In addition to the test at the completion of each installation, certain tests shall be done during the progress of the Works, as required by clauses 19.4 to 19.8 inclusive, 19.12 and relevant standards.

19.2 INFORMATION

19.2.1 For equipment supplied under the Contract, the Contractor shall obtain from Manufacturers the time/current characteristics of all protective devices for automatic disconnection of supply, and provide copies to the Project Manager and to the person or persons carrying out the inspection and testing, in addition to meeting the requirements of clause 20.5.1.

19.3 TESTING METHODS

19.3.1 The Project Manager shall be notified of the method to be used for each type of test and the notification shall be given not less than 28 days before the tests are to be made.

19.3.2 Testing procedures for continuity of protective conductors and equipotential bonding shall be in accordance with the IEE Guidance Notes.

19.3.3 Voltage tests on HV cables and, where indicated, on LV cables, type tested and partially type tested assemblies and transformers shall comply with the requirements of site testing in the appropriate British Standards.

19.3.4 Alternative methods may be proposed for the approval of the Project Manager, but they shall be no less effective than those set out in the British Standards.

19.3.5 Equipment shall be disconnected for the duration of the relevant tests, where necessary, to prevent damage to components of equipment.

19.4 POWER CABLES

19.4.1 Tests shall be made immediately on completion of the installation of power cables to demonstrate that the phase sequence is correct at all end connections.

19.4.2 HV cables and, where indicated, LV cables shall be tested in accordance with clause 19.3.3 as soon as their installation is complete.

19.4.3 Where indicated, the oversheaths of cables laid underground shall be given a voltage withstand test after backfilling of the trenches is complete but before termination.

19.5 ALARM, CONTROL, COMMUNICATION AND MONITORING CABLES

19.5.1 Cables shall be tested as soon as their installation is complete to ensure that the cores are continuous, that they have not been crossed and that the insulation resistance is satisfactory. Insulation tests shall cover all permutations between each conductor, screen, metallic sheath, armour and earth.

19.6 CONDUIT AND TRUNKING

19.6.1 Where conduit is cast in-situ in reinforced concrete it shall be checked for freedom from blockage and steel conduit shall be tested for electrical continuity before casting and as soon as practicable after casting.

19.6.2 Steel conduit and trunking systems shall be inspected and tested before any wiring is installed; underfloor ducting and flush floor trunking shall be inspected and tested before screeding.

19.7 EARTH ELECTRODES

19.7.1 The resistance of each earth electrode,

whether for earthing of protective conductors, lightning protection or an electrical system, shall be checked as described in BS 7430 immediately after installation of the electrodes and the results submitted to the Project Manager.

19.8 LIGHTNING PROTECTION

19.8.1 Where the reinforcement of a concrete structure is indicated to form the down conductors, the electrical continuity of the reinforcing bars shall be tested after each pour of concrete is completed (clause 17.3.5 refers).

19.8.2 At the completion of the whole lightning protection installation it shall be inspected and tested in accordance with BS 6651.

19.9 EARTH FAULT LOOP IMPEDANCES

19.9.1 The measured earth fault loop impedance for each circuit shall be checked. Where the maximum value is exceeded, the Project Manager shall be consulted.

19.10 EMERGENCY LIGHTING SYSTEMS

19.10.1 Emergency lighting systems shall be inspected and tested in accordance with the "three-yearly" inspection and test procedure laid down in BS 5266.

19.11 POTENTIALLY EXPLOSIVE ATMOSPHERES

19.11.1 Installations in potentially explosive atmospheres shall be inspected and tested in accordance with all the relevant requirements of this Section and with the requirements of BS EN 60079.

19.12 CATHODIC PROTECTION

19.12.1 Cathodic protection installations shall be tested during the commissioning period in accordance with BS 7361.

19.12.2 Before pipework and structure is covered by backfilling, every joint in the protected metalwork shall be tested. Where the resistance is not sufficiently low in relation to the total circuit to allow adequate current to pass, the joint shall be bonded in accordance with clause 18.5.3.

19.13 RECORDS AND CERTIFICATES

19.13.1 Inspection and test results shall be recorded on the forms provided by the Project Manager. Two copies shall be submitted to the Project Manager within seven days of each test.

19.13.2 When all inspections and tests results are satisfactory, Electrical Installation Certificates shall be given to the Project Manager not later than the date of completion of the Works. The Certificates shall be given in the form laid down in BS 7671, BS 5839 for fire alarm systems and BS 5266 for emergency lighting systems.

19.13.3 The type of earthing employed, the values of prospective short-circuit current and earth fault loop impedance at the origin of the installation shall be recorded on the Electrical Installation Certificates.

Section Twenty – Drawings and Documents by Contractor

20.1 EXTENT OF PROVISION

20.1.1 Unless otherwise indicated, the Contractor shall provide the drawings and documents specified in this Section.

20.1.2 General layout drawings shall be drawn to a scale of 1:100 or 1:50 as indicated and detailed layout assembly drawings to a scale of 1:20. If more detail is necessary scales of 1:10, 1:2 and 1:1 may be used.

20.1.3 The numbers of sets of drawings and documents to be supplied shall be as indicated.

20.2 INSTALLATION DRAWINGS AND DOCUMENTS

20.2.1 Installation drawings and documents, including diagrams and schedules, shall show the details of the Contractor's proposals for the execution of the Works and shall include everything necessary for the following purposes:

to illustrate in detail the arrangement of the various sections of the Works and to identify the various components;

to integrate the Works with the detail of the building and other installations.

20.2.2 Installation drawings shall include:

general layout drawings showing the location of all equipment including cable, cable tray, conduit, trunking, ducting and earth electrodes;

detailed layout drawings showing the location of all equipment including cable, cable tray, conduit, trunking, ducting in switchrooms and plant rooms;
assembly drawings of factory built equipment and site built assemblies;

detailed layout drawings showing the connection of cable, conduit and trunking to equipment;

detailed layout drawings showing sections through ceiling voids and vertical shafts;

system diagrams, circuit diagrams and wiring diagrams for all installations and equipment.

20.2.3 Diagrams shall comply with BS 5070 and BS EN 61082. Interconnection diagrams shall indicate the type of cable, conductor size and terminal numbering.

20.3 BUILDER'S WORK DRAWINGS

20.3.1 Builder's work drawings shall show fully dimensioned details of all builder's work required in connection with the Works together with the overall size and weight of equipment.

20.4 AS-INSTALLED DRAWINGS

20.4.1 As-installed drawings, including diagrams and schedules, shall show all the information necessary so that each installation can be operated, maintained, inspected and tested so as to prevent danger, as far as is reasonably practicable. They shall incorporate the information necessary for the identification of the devices performing the functions of protection, isolation and switching, and their locations. The values of prospective short circuit current and earth fault loop impedance at all material locations of the installation shall be recorded on the appropriate system documentation.

20.4.2 The drawings shall include those set out in clause 20.2.2.

20.4.3 Circuit details including loading, origin, route, destination and, where buried, the depth below finished ground level shall be shown for each cable, conduit, trunking and ducting. Conductor size and material and the type of insulation of all cables shall be shown together with the number of cores in each cable or the number of cables in each conduit, trunking or ducting. Where identification is by colour of insulation or sheath this shall be shown. Joints and draw-in boxes shall be shown.

20.4.4 Where incoming supply cables are installed by others they shall also be shown as described in Clause 20.4.3.

20.4.5 Drawings shall indicate whether conduit, trunking or ducting is surface mounted, concealed in ceiling spaces, in wall chases, in floor screeds or cast in-situ.

20.4.6 All earthing conductors, main equipotential bonding conductors, main earthing terminal or bar, protective conductors shall be identified with function, origin, route, destination, conductor size and material, type of insulation and, where buried, the depth below finished ground level. Test points shall be indicated.

20.4.7 Earth electrodes shall be identified, showing their type, dimensions, material and depth below finished ground level. The nature of the soil and any treatment that has been given to it or special fill that has been used in the installation shall be identified.

20.4.8 Details of each item of equipment, including luminaires, shall include electrical characteristics, classification, degree of protection against ingress of solids and liquids, class of protection against corrosion and Manufacturer's name and reference.

20.4.9 Diagrams shall comply with clause 20.2.3 and, where necessary, they shall be supplemented with physical arrangement drawings to assist the location and identification of component parts of equipment.

20.4.10 Drawings of the lightning protection system shall include identification of those elements of the building fabric used as air terminations and down conductors. Details of connection to structural steel frames or to the reinforcement of a concrete structure shall be included. Details of earth electrodes shall comply with clause 20.4.7. Test clamps shall be identified.

20.4.11 During the course of the Works the Contractor shall maintain a fully detailed record of all changes, which shall be available to the Project Manager, to ensure the as-installed drawings are in all respects accurate.

20.4.12 Each drawing shall be in accordance with BS 308, or the relevant BS EN ISO document that replaced it and delivered in the format and medium required in the Particular Specification. The words "AS-INSTALLED" shall be placed in 19mm block letters adjacent to the title block of each drawing together with the name of the site and the section of the Works, the title of the installation, the date of completion of the Works, the Contract number and the name of the Contractor.

20.4.13 A draft of each as-installed drawing shall be submitted to the Project Manager for approval before final issue is made.

20.5 MAINTENANCE AND OPERATING INSTRUCTIONS

20.5.1 For each electrical installation, system and individual equipment forming part of the Works, the Maintenance and Operating instructions shall include:

the information specified for Manuals Class D in Building Services Research & Information Association (BSRIA) Application Guide 1/87;

a description of the extent and manner of operation, including duration periods of standby systems;

a description of the method used for compliance with Regulation 413-02 of BS 7671 together with time/current characteristics for all protective devices for automatic disconnection of supply;

a copy of any Certificates of Compliance with relevant standards or schemes as required by clauses 1.5.2 and 1.5.3;

comprehensive instructions for the switching on, operation, switching off and isolation of circuits/systems and for dealing with emergency conditions;

instructions for any precautionary measures necessary;

instructions for servicing, including frequency and materials to be used, to maintain the equipment in good and safe condition;

the names and addresses of Suppliers of all major components together with the type and model reference, serial number, duty rating and the order number and date.

20.5.2 Maintenance and Operating instructions shall be indexed and contained in ring binders with rigid covers. The name of the site and the Contract number shall be printed on the front and spine with a suitable identification title (where more than one volume is necessary). The date of completion of the Works shall be included on a flyleaf.

20.5.3 Copies of Manufacturer's data may be incorporated to supplement the descriptions and instructions required in clause 20.5.1 but shall not replace them. Only data relevant to the Works shall be included, and where non-relevant information appears on the same sheet it shall be clearly marked to show that it is not applicable. The information shall be cross-referenced within the text and included in the index, and, if possible, it shall be contained in the ring binders. Where this is not possible suitably protected box files or folders shall be provided, identified in accordance with clause 20.5.2.

20.5.4 A draft of the Maintenance and Operating instructions shall be submitted to the Project Manager for approval. Any amendments required shall be made before the Project Manager accepts final documentation.

Appendix One - List of Standards

The following Standards and other documentation are referred to in this Specification:

1. British Standards

BS 65:1991.	Spec for vitrified clay pipes, fittings and ducts, also flexible mechanical joints for use solely with surface water pipes and fittings.
BS 88.	Cartridge fuses for voltages up to and including 1000V a.c. and 1500V d.c.
BS 215.	Spec for aluminium conductors, steel-reinforced for overhead power transmission.
BS 308.	Engineering Drawing Practice. **Withdrawn. Replaced by various BS EN's.**
BS 476.	Fire tests on building materials and structures.
BS 1361:1971.	Specification for cartridge fuses for a.c. circuits in domestic and similar premises.
BS 1387:1985.	Specification for screwed and socketed steel tubes and tubulars and for plain end steel tubes suitable for welding or for screwing to BS 21 pipe threads.
BS 1494.	Specification for fixing accessories for building purposes. Fixings for sheet, roof and wall coverings.
BS 1710:1984.	Specification for identification of pipelines and services.
BS 2782.	Methods of testing plastics.
BS 3506:1969.	Specification for unplasticized PVC pipe for industrial uses.
BS 3535.	Isolating transformers and safety isolating transformers.
BS 3573:1990.	Specification for polyolefin copper-conductor telecommunication cables.
BS 3924:1978.	Specification for pressure-sensitive adhesive tapes for electrical insulating purposes.
BS 3955:1986.	Specification for electrical controls for household and similar general purposes.
BS 4177:1992.	Specification for cooker control units.
BS 4345:1968.	Specification for slotted angles.
BS 4533.	Luminaires.
BS 4573:1970.	Specification for 2-pin reversible plugs and shaver socket-outlets.
BS 4579.	Specification for performance of mechanical and compression joints in electric cable and wire connectors.
BS 4660:2000.	Thermoplastics ancillary fittings of nominal sizes 110 and 160 for below ground gravity drainage and sewerage.

BS 4662:1970.	Specification for boxes for the enclosure of electrical accessories.
BS 4678.	Cable trunking.
BS 4683.	Specification for electrical apparatus for explosive atmospheres.
BS 4921:1988.	Specification for sherardized coatings on iron or steel.
BS 4999.	General requirements for rotating electrical machines.
BS 5000.	Specification for rotating electrical machines of particular types or for particular applications.
BS 5042:1987.	Specification for bayonet lampholders. **Withdrawn. Replaced by BS EN 61184:1995.**
BS 5070.	Engineering diagram drawing practice.
BS 5266.	Emergency lighting.
BS 5467:1997.	Specification for 600/1000V and 1900/3300V armoured electric cables having thermosetting insulation.
BS 5481:1977.	Specification for unplasticized PVC pipe and fittings for gravity sewers.
BS 5501.	Electrical apparatus for potentially explosive atmospheres.
BS 5518:1977.	Specification for electronic variable control switches (dimmer switches) for tungsten filament lighting.
BS 5649.	Lighting columns.
BS 5669.	Particleboard. **Withdrawn. Replaced by various BS EN's.**
BS 5685.	Electricity meters.
BS 5839.	Fire detection and alarm systems for buildings.
BS 6004:2000.	Electric cables. PVC insulated, non-armoured cables for voltages up to and including 450/750V, for electric power, lighting and internal wiring.
BS 6031:1981.	Code of practice for earthworks.
BS 6121.	Mechanical cable glands.
BS 6207.	Mineral insulated cables with a rated voltage not exceeding 750V.
BS 6220:1983.	Specification for junction boxes for use in electrical installations with rated voltages not exceeding 250V.
BS 6346:1997.	Specification for 600/1000V and 1900/3300V armoured electric cables having PVC insulation.
BS 6480:1988.	Specification for impregnated paper-insulated lead or lead alloy sheathed electric cables of rated voltages up to and including 33000V.
BS 6485:1999.	PVC-covered conductors for overhead power lines.

BS 6622:1999.	Specification for cables with extruded cross-linked polyethylene or ethylene propylene rubber insulation for rated voltages from 3.8/6.6kV up to 19/33kV.
BS 6651:1999.	Code of practice for protection of structures against lightning.
BS 6701:1994.	Code of practice for installation of apparatus intended for connection to certain telecommunication systems.
BS 6724:1997.	Specification for 600/1000V and 1900/3300V armoured electric cables having thermosetting insulation and low emission of smoke and corrosive gases when affected by fire.
BS 6910.	Cold pour resin compound and heat-shrink cable joints in the voltage range up to 1000V a.c. and 1500V d.c.
BS 6941:1988.	Specification for electrical apparatus for explosive atmospheres with type of protection N.
BS 6946:1988.	Specification for metal channel cable support systems for electrical installations.
BS 6972:1988.	Specification for general requirements for luminaire supporting couplers for domestic, light industrial and commercial use.
BS 7917:1990.	Specification for performance of bonds for electric power cable terminations and joints for system voltages up to 36kV.
BS 7211:1998.	Specification for thermosetting insulated cables (non-armoured) for electric power and lighting with low emission of smoke and corrosive gases when affected by fire.
BS 7361.	Cathodic protection.
BS 7430:1998.	Code of practice for earthing.
BS 7535:1992.	Guide to the use of electrical apparatus complying with BS 5501 or BS 6941 in the presence of combustible dusts.
BS 7671:2001.	Requirements for electrical installations. IEE Wiring Regulations. Sixteenth edition.
BS 7884:1997.	Specification for copper and copper-cadmium stranded conductors for overhead electric traction and power transmission systems.
BS 7888.	LV and MV accessories for power cables with rated voltage from 0.6/1kV (U_m=1.2kV) up to and including 20.8/36kV (U_m=42kV).
BS 7889:1997.	Specification for 600/1000V single-core unarmoured electric cables having thermosetting insulation.
BS 7919:2001.	Electric cables. Flexible cables rated up to 450/750V, for use with appliances and equipment intended for industrial and similar environments.
BS 8000.	Workmanship on building sites.
BS 8110.	Structural use of concrete.
BS EN 40.	Lighting columns.
BS EN 681.	Elastomeric seals. Material requirements for pipe joint seals used in water and drainage applications.
BS EN 1011.	Welding. Recommendations for welding of metallic materials.

BS EN 10025:1993.	Hot rolled products of non-alloy structural steels. Technical delivery conditions.
BS EN 10111:2002.	Metallic and other inorganic coatings. Measurement of mass per unit area. Review of gravimetric and chemical analysis methods.
BS EN 10113.	Hot-rolled products in weldable fine grain structural steels.
BS EN 10130:1999.	Cold-rolled low-carbon steel flat products for cold forming. Technical delivery conditions.
BS EN 10131:1991.	Cold-rolled uncoated low carbon and high yield strength steel flat products for cold forming. Tolerances on dimensions and shape.
BS EN 10147:2000.	Continuously hot-dip zinc coated structural steels strip and sheet. Technical delivery conditions.
BS EN 10149.	Specification for hot-rolled flat products made of high yield strength steels for cold forming.
BS EN 10162:2003.	Cold rolled steel sections. Technical delivery conditions. Dimensional and cross-sectional tolerances.
BS EN 13601:2002.	Copper and copper alloys. Copper rod, bar and wire for general electrical purposes.
BS EN 22063:1994.	Metallic and other inorganic coatings. Thermal spraying. Zinc, aluminium and their alloys.
BS EN 50014:1998.	Electrical apparatus for potentially explosive atmospheres. General requirements.
BS EN 50015:1998.	Electrical apparatus for potentially explosive atmospheres. Oil immersion "o".
BS EN 50016:2002.	Electrical apparatus for potentially explosive atmospheres. Pressurized apparatus "p".
BS EN 50017:1998.	Electrical apparatus for potentially explosive atmospheres. Powder filling "q".
BS EN 50018:2000.	Electrical apparatus for potentially explosive atmospheres. Flameproof enclosure 'd'.
BS EN 50019:2000.	Electrical apparatus for potentially explosive atmospheres. Increased safety 'e'.
BS EN 50020:2002.	Electrical apparatus for potentially explosive atmospheres. Intrinsic safety 'i'.
BS EN 50183:2000.	Conductors for overhead lines. Aluminium-magnesium-silicon alloy wires.
BS EN 50281.	Electrical apparatus for use in the presence of combustible dust.
BS EN 55015:2001.	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment.
BS EN 60079.	Electrical apparatus for explosive gas atmospheres.
BS EN 60269.	Low-voltage fuses.
BS EN 60309.	Plugs, socket-outlets and couplers for industrial purposes.
BS EN 60439.	Specification for low-voltage switchgear and controlgear assemblies.
BS EN 60446:2000.	Basic and safety principles for man-machine interface, marking and identification. Identification of conductors by colours or numerals.

BS EN 60529:1992.	Specification for degrees of protection provided by enclosures (IP code).
BS EN 60598.	Luminaires.
BS EN 60730.	Specification for automatic electrical controls for household and similar use.
BS EN 60898.	Specification for circuit-breakers for overcurrent protection for household and similar installations.
BS EN 60920:1991.	Ballasts for tubular fluorescent lamps. General and safety requirements.
BS EN 60921:1991.	Specification for ballasts for tubular fluorescent lamps. Performance requirements.
BS EN 60922:1997.	Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). General and safety requirements.
BS EN 60923:1996.	Auxiliaries for lamps. Ballasts for discharge lamps (excluding tubular fluorescent lamps). Performance requirements.
BS EN 60928:1995.	Auxiliaries for lamps. a.c. supplied electronic ballasts for tubular fluorescent lamps. General and safety requirements.
BS EN 60929:1992.	Specification for a.c. supplied electronic ballasts for tubular fluorescent lamps. Performance requirements.
BS EN 60947.	Specification for low-voltage switchgear and controlgear.
BS EN 60998.	Connecting devices for low-voltage circuits for household and similar purposes.
BS 61008.	Specification for residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs).
BS EN 61009.	Specification for residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs).
BS EN 61036:1997.	Alternating current static watt-hour meters for active energy (classes 1 and 2). **Withdrawn. Replaced by BS EN 62053-21:2003.**
BS EN 61058.	Switches for appliances.
BS EN 61082.	Preparation of documents used in electrotechnology.
BS EN ISO 1461:1999.	Hot dip galvanized coatings on fabricated iron and steel articles. Specifications and test methods.

2. Electricity Association Technical Standards (can be downloaded via www.electricity.org.uk)

TS 09-9.	Polymeric insulated, combined neutral/earth (CNE) cables with solid aluminium phase conductors and concentric aluminium wire waveform neutral/earth conductor. EA, 1981, Issue 5.
TS 43-30.	Low voltage overhead lines on wood poles. EA, 1981, Issue 2.
TS 43-40.	High voltage single circuit overhead lines on wood poles. EA, 1988, Issue 1.

3. International Electrotechnical Commission

IEC 60502.	Power cables with extruded insulation and their accessories for rated voltages from 1kV up to 30kV.

4. DE Functional Standard (can be downloaded via www.defence-estates.mod.uk)

Design and Maintenance Guide (DMG) 08. Space Requirements for plant access, operation and maintenance. DEO, 1996. ISBN 0117727857.

5. IEE Guidance Notes

Guidance Note 1.	Selection and Erection of Equipment, IEE 4th Edition, 0852969899.
Guidance Note 2.	Isolation and Switching, IEE, 4th Edition, ISBN 0852969902.
Guidance Note 3.	Inspection and Testing, IEE, 4th Edition, ISBN 0852969910.
Guidance Note 4.	Protection against Fire, IEE, 3rd Edition, ISBN 0852969570.
On Site Guide	(BS 7671:2001, 16th Edition Wiring Regulations), IEE, ISBN 0852969872.

6. Industry Standards (can be downloaded via www.icel.co.uk)

ICEL 1001:1999.	Scheme of product and Authenticated Photometric Data Registration for Emergency Luminaires and Conversion Modules. ICEL, 1999.
ICEL 1004:2003.	Requirements for the Re-Engineering of Luminaires for Emergency Lighting Use. ICEL, 2003.
ICEL 1006:1999.	Emergency Lighting Guide. ICEL, 3rd Edition, 1999.
ICEL 1008:2001.	Risk Assessment Guide. ICEL, 3rd Edition, 2001.
ICEL 1009:2001.	Emergency Lighting Central Power Supply Systems Standard and Registration Scheme. ICEL, 2001.

7. BSRIA

Application Guide (AG) 1/87.1. Operating and Maintenance Manuals for Building Services Installations, Armstrong, J.H. BSRIA, 1990, ISBN 0860222551.

8. Health and Safety at Work etc. Act 1974. HMSO, 1974, ISBN 0102156832.

9. SI 1966 no. 94. Construction (Working places) Regulations 1966. HMSO, 1966.

10. SI 1988 no. 1057. Electricity Supply Regulations 1988. HMSO, 1988, ISBN 0110870573.

11. SI 1989 no. 635. Electricity at Work Regulations 1989. HMSO, 1989, ISBN 011096635X.

12. SI 1994 no. 3140. Construction (Design and Management) Regulations 1994. TSO, 1994, ISBN 0110438450.

13. SI 2002 no. 2665. Electricity Safety, Quality and Continuity Regulations 2002. TSO, 2002, ISBN 0110429206

14. SI 2002 no. 2677. Control of Substances Hazardous to Health (COSHH) Regulations 2002. TSO, 2002, ISBN 0110429192.

15. SI 2002 no. 2776. Dangerous Substances and Explosive Atmospheres Regulations 2002 (DSEARR). TSO, 2002, ISBN 0110429575.