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Job No: VBS-0126 L5 3PE

Doc Ref: VBS Doc A Electrical Building Services Workmanship Specification

Latest Revision: A

Date: 15/02/2026

Electrical Building Services Workmanship Specification

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Revision Schedule

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1. INSTALLATION STANDARDS

1.1. General

- 1.1.1. All electrical installation works, including design, construction, inspection and testing and commissioning shall only be carried out by a Contractor competent to carry out such works as described in the Particular and General Electrical Specifications. The Contractor shall provide adequate fully trained, competent electrical operatives for the works, to undertake and construct the works safely and in accordance with the requirements of the programme.
- 1.1.2. In the specification, the Electrical Contractor shall hereinafter be referred to as the Contractor. It is a matter of contractual arrangement on any works how the parties shall be identified and “Contractor” may need to be reinterpreted accordingly. The “Engineer” shall be the person, persons or company supervising the works on behalf of the owner or Client and likewise this shall be interpreted accordingly in any agreements.

1.2. General Workmanship

- 1.2.1. All works carried out by the Contractor shall be of a high standard and shall enable the systems to be complete and function in the most effective manner.
- 1.2.2. The Particular Specification accompanying this specification shall override any conflicting requirements with this General or Workmanship specification.
- 1.2.3. All materials, products and workmanship shall comply with all current British legislation and regulations; which include, but are not limited to, the following:
 - Government Rules and Building Regulations
 - BS 7671 Requirements for Electrical Installations Latest Edition
 - Safety and Health at Work Act and Regulations made under this Act
 - Public Health Acts
 - Control of Pollution Acts
 - Local Authority Byelaws and Regulations
 - Control of Substances Hazardous to Health Regulations
 - Asbestos Regulations
 - The Electricity Supply Regulations
 - British Standards
 - Water Supply Authority Regulations and Requirements
 - Gas Supply Authority Requirements and Safety Regulations
 - Electricity Supply Authority Requirements and Regulations
 - Loss Prevention Council rules
 - LDSA Fire, Safety Guide
 - National Telecommunications Regulations
- 1.2.4. The Contractor shall provide attendance for, and inspection in connection with all the above, and shall liaise with the Building Inspector, Environmental Health Officer, Highway Engineer, Medical Officer, Refuse Engineer, Fire Officer etc., as necessary or ensure their satisfaction with the works.
- 1.2.5. The Contractor shall pay all charges made by any authority in approving any part of the works, and shall notify the Engineer of any revisions or additions to the above publications which occur during the installation of the works.

1.3. Materials

- 1.3.1. Where certificates are furnished by the manufacturer stating that the materials comply in all respects with a relevant standard, the Contractor shall obtain and forward these to the Engineer. Any changes arising from these requirements are to be included in the tender sum.
- 1.3.2. Commodities specified to conform to British Standards shall be clearly indelibly marked with the reference specified. Where this is impractical, the relevant advice and delivery notes shall include the BS reference with which they comply.
- 1.3.3. Where commodities are specified as manufactured by a BSI Kitemark Licensee or where commodities/services are specified to be by Registered Firms (under BSI Assessment Schemes) the manufacturer/firm must be a current participant in the relevant scheme.
- 1.3.4. Where commodities or systems are specified as certified by the British Board of Agreement the commodities or systems supplied shall be subject to a current BBA certificates.

- 1.3.5. Where commodities or services are specified to be registered/approved firms, under Approved Quality Assurance Schemes, the manufacturer/firm must be a current participant in the relevant scheme.
- 1.3.6. The equipment and/or installation shall conform to the relevant British Standards and current Codes of Practices three months prior to the date for return of tenders, unless indicated otherwise. Certificates of Compliance shall be provided to the engineer at their request.
- 1.3.7. Generally with reference to the quality of materials the tender prices shall be deemed to include the
- 1.3.8. Suitable for the purposes of the works stated in or reasonably inferred from the Contract specifications and/or drawings.
- 1.3.9. In accordance with good building practice, including the relevant provisions of current BS Specifications and/or documents.
- 1.3.10. Where approval of products or materials is specified, samples or other evidence of suitability are to be provided. Orders for materials are not to be confirmed until approval has been given by the Engineer. Approved samples are to be retained on site for comparison with products and materials used in the works and finally removed when no longer required.
- 1.3.11. Where samples of finished work are specified, approval of stated characteristics shall be obtained before the works are proceeded with.
- 1.3.12. Samples which are not part of the finished work shall be removed on completion.
- 1.3.13. Where, and to the extent that products, materials and work are specified "To be Approved" or the Engineer instructs or requires that they are to be approved, the same must be supplied and executed to comply with all other requirements and in respect of the stated or implied characteristic(s) either.
- 1.3.14. To the express approval of the engineer
OR
- 1.3.15. To match a sample expressly approved by the Engineer as a standard for the purpose.
- 1.3.16. Inspection or any other action taken by the Engineer must not be taken as approval of materials, product or works, unless the Engineer confirms in writing, in express terms, referring to:-
 - Date of inspection.
 - Part of the works inspected.
 - Respects of characteristic(s) which are approved.
 - Extent and purpose of the approval.
 - Any associated conditions.
- 1.3.17. Materials are to be suitable for the climatic conditions in the area in which the project is located.
- 1.3.18. Where necessary all materials or equipment shall comply with the relevant standards necessary to comply with necessary European Directives implemented in UK legislation. The materials or equipment shall be properly and clearly "CE" marked.
- 1.3.19. Materials and equipment not manufactured in the U.K shall require evidence of compliance with British Standards by tests carried out by a recognised authority. Spares and replacement parts shall be obtainable in the country of installation.
- 1.3.20. All equipment delivered to site shall be clearly marked with the manufacturer's name, brand name, or any other data that may be required to verify the exact nature of the equipment or materials, and relate it to the requirements of the specification. Where necessary the required CE marking shall be clearly visible.
- 1.3.21. The Engineer may request, throughout the duration of the project, samples of components and materials the Contractor proposes to use. These must be supplied as required by this specification at the Contractors cost.
- 1.3.22. Samples shall be identical in all respects with the material that it is proposed to include in the works and shall be of adequate size or quantity to permit proper evaluation and review. Relevant manufacturer's literature shall accompany all samples.
- 1.3.23. Any work carried out prior to samples being submitted and approved in writing shall be at the Contractors risk. Any material not approved shall be removed and replaced at the Contractors cost.

1.4. Site Operations

1.4.1. Fire Precautions :

- 1.4.1.1. All necessary precautions shall be taken to prevent any outbreak of fire. This shall include where site welding is carried out, where the Contractor shall take all necessary precautions to prevent fire damage to inflammable building materials.
- 1.4.1.2. All cables, ducts and pipes shall be sealed in accordance with relevant regulations where they pass through floors, structural walls and fire barriers.
- 1.4.1.3. Any flammable solvents, paint gases or other fluids shall be stored in a purpose made external enclosure displaying the statutory notices.
- 1.4.1.4. Control of Electrical Equipment :
- 1.4.1.5. During the construction works the Contractor shall be responsible for full control of all electrical systems and equipment within the work area and for all switching operations associated with the works. When not required, isolators shall be locked in the "OFF" position

1.4.2. Oil and Grease :

- 1.4.2.1. All necessary oils and grease shall be supplied by the Contractor for the first filling of starters, wells in bearings etc. All shall then be kept topped up as necessary for all commissioning procedures and up to practical completion.

1.4.3. Fuel :

- 1.4.3.1. The Contractor shall provide all necessary fuel for the site testing, commissioning and subsequent filling of the fuel tanks for all necessary equipment such as generators, engines etc.

1.4.4. Keys :

- 1.4.4.1. Unless specifically stated to the contrary elsewhere in this Contract, the Contractor shall supply three keys and spanners of each size for all key operated equipment and enclosures supplied under this contract. All tools and keys shall be suitably identified and handed to the Engineer at completion of works.

1.4.5. Satisfactory Appearance :-

- 1.4.5.1. The complete installation shall be of a neat appearance and to the satisfaction of the Engineer. Any installation or part that is not approved as such shall be removed and re-fitted at the Contractors cost. All cable, conduit, trunking routes etc. shall be square with the building and follow the building line unless agreed otherwise in writing with the Engineer.

1.4.6. Notice to Cover :

- 1.4.6.1. The Contractor shall give seven days' notice of intention to cover any services. Failure to do so shall require his uncovering and recovering such services, if required by the Engineer for inspection or any other reason, at the Contractors cost.

1.4.7. Suppression :

- 1.4.7.1. All electrical plant and equipment shall have necessary suppression equipment to prevent any interference with radio, television, telephone and security systems, and comply with the EMC Regulations.

1.5. Regulating and Performance Tests

- 1.5.1. Upon completion of works the Contractor shall, when required by the Engineer, demonstrate the ability of any section of the plant or its components to function as required by the specification.
- 1.5.2. All equipment shall be supplied and all works carried out with due regard being given to their inspection, cleaning, repair and future maintenance or extension.
- 1.5.3. The metric system of measurement units shall be used throughout for the detailing and manufacturing of equipment and for the setting out of the works. Where equipment or parts thereof can only be supplied in imperial sizes, the Engineer shall be informed prior to order.
- 1.5.4. All items of equipment shall be adequately ventilated, using mechanical means if necessary, to dispel any heat produced or dust or fumes generated by the equipment. The Contractor shall be responsible for ensuring that maximum ambient operating temperatures or conditions are obtained from the

manufacturer, where these are not defined in the particular specification, and that this information is passed on to the Engineer prior to order.

- 1.5.5. For each item of equipment the Contractor shall obtain general arrangement drawings, constructional details, fixing or mounting information, electrical schematic diagrams and wiring diagrams as appropriate. These shall be in accordance with good drawing office practice and shall use symbols described in BSEN 60617. Each drawing shall give a full description of the equipment, a drawing title, a particular reference for the item of equipment and the Manufacturer's name and details.
- 1.5.6. Where equipment is provided with a guarantee by the manufacturer, the Contractor shall ensure that the benefits of the guarantee are enjoyed by the client for the full period, commencing from the date of handover. Where a manufacturer offers an improved or amended guarantee particular to a specific project, this shall be brought to the attention of the Engineer. Where the terms of any guarantee offered by a manufacturer in any way seek to alter the Statutory Rights of the Client, this shall also be brought to the attention of the Engineer.
- 1.5.7. Materials used in the manufacture of equipment shall not include :
 - Asbestos, in any form.
 - Sulphur Hexafluoride (SF6)
 - Polychlorinated Biphenyl.
 - Radioactive substances (unless called for in the particular specification).
 - Wherever possible, any material or substance not classified as non-combustible or self-extinguishing.
 - Wherever possible, plastics other than those with low smoke and zero halogen gas emission during combustion.
 - Rubber (unless called for in the particular specification).
 - Any substance known to be a pollutant to the environment.
 - Any CFC or CFC-blown based material.
- 1.5.8. All potentially dangerous equipment shall have fully adequate safety signs, externally and internally, to impart prohibition, warning, mandatory and safe working instructions as necessary. These shall be in accordance with BS 5378.

1.6. Pre-Ordered Equipment

- 1.6.1. Where equipment has been pre-ordered, prior to tender, in order to expedite delivery on programme, it is the sole responsibility of the Contractor who places the actual order, to ensure that such plant or equipment conforms in every detail to all relevant clauses of the specification.

1.7. Electrical Power Supply

- 1.7.1. A low voltage supply is preferred wherever this can be provided by the Supply Authority. Where a high voltage supply is necessary, this shall be fully discussed and agreed with the Engineer.
- 1.7.2. All low voltage supplies shall preferably have a TN-S arrangement but a TN-C-S arrangement shall be acceptable where this is provided as standard by the Supply Authority. The supply shall have declared parameters of 400/230 volts (+10%-6%) with earthed neutral, 3-phase, 4-wire 50 Hertz alternating current. For both the TN-S and the TN-C-S supply arrangements a separate main earthing terminal shall be provided to which the Contractor shall arrange for all services to be main bonded. In the case of the TN-C-S supply arrangement the contractor shall ensure that any declaration required by the Supply Authority is made in respect of the bonding.
- 1.7.3. Negotiations with the Supply Authority shall generally be carried out by the Engineer. Where they are to be carried out by the Contractor however they shall be in accordance, where relevant, with the following procedures :-
 - 1.7.3.1. Estimation of maximum demand :
 - Estimations for initial design purposes shall be carried out by the Engineer. In all cases before any approach is made to the Supply Authority, the Contractor shall discuss and agree the design requirements with the Engineer. An allowance must always be included of an estimation of the future growth for the premises.

1.7.3.2. Point of supply and metering :-

- For a low voltage supply, the point of supply and metering shall preferably be at the main low voltage switchroom. Where the point of supply is remote from the low voltage switchroom, or a sub-station is required, the metering location shall be carefully considered and a suitable location chosen to be accessible at all reasonable times to the Supply Authority. The location shall be protected against tampering, mechanical damage, or vandalism, especially where the metering is accessible from the exterior of the building. Where the Supply Authority have a standard exterior metering enclosure, this shall be used wherever possible for exterior metering.
- The point of supply metering shall not be incorporated into the main low-voltage switchboard.

1.7.3.3. Supply balance :-

- The Contractor shall take every care to ensure that the load attached to the Supply Authority terminals is reasonably balanced between the phases at all times.
- Phase balance at the point of supply is most essential when bulk or supplementary bulk power factor correction is applied to ensure correct operation of the sensing relay and switching of the correct amount of capacitance.

1.7.3.4. Power Factor Correction :-

- The Contractor shall ensure that the power factor of the load applied to the Supply Authority terminals is that which provides the most favourable tariff. Where power factor correction (PFC) is required, it shall be by the use of bulk correction at the point of supply. A fully automatic system shall be installed, using multi-stage capacitor banks, with each step no greater than 50 kVAr. The capacitors shall be controlled by a suitable multi-stage, purpose built, PFC relay. The complete PFC system is to be housed in a purpose made enclosure adjacent to the main switch panel.
- In certain circumstances the Engineer may sanction the use of remote direct-on-line PFC units, for example to large motive loads. The Contractor shall, in this event, obtain the approval of the Engineer.
- The Contractor shall ensure that all PFC substances used are non-carcinogenic and non-toxic. The use of PCB substances is totally prohibited.

1.7.3.5. Earthing:

- Where the Supply Authority does not provide an earth terminal, the Contractor shall design and install a suitable earth terminal to comply with the requirements of the Electricity Supply Regulations and BS7671 and to the approval of the Engineer.

1.8. Suitability of Materials and Products

- 1.8.1. All equipment shall preferably be designed and manufactured to a Quality Assurance scheme assessed to meet the requirements of BS 5750 or ISO 9000. The Contractor shall bring to the attention of the Engineer any equipment not subject to such a scheme.
- 1.8.2. All materials shall be new and of types and qualities described, at least equal to approved samples.
- 1.8.3. As soon as practicable after receiving the order to commence the works the Contractor shall confirm to the Engineer the names of suppliers from whom they propose to obtain any materials, but he shall not place any order without approval of the Engineer which may be withheld until samples have been submitted and satisfactorily tested. The Contractor shall thereafter keep the Engineer informed of orders for and delivery dates of all materials.
- 1.8.4. Materials shall be transported, handled and stored in such a manner as to prevent deterioration, damage or contamination. Any materials which in the opinion of the Engineer do not meet these requirements shall be removed from site and replaced at the Contractors expense.
- 1.8.5. Materials and products shall be supplied to suit the temperatures and other conditions normally expected during transit, storage, installation and use, and also to withstand any test specified in the contract documents.
- 1.8.6. The general atmospheric conditions under which the equipment will be required to work may be polluted with industrial fumes or salt air and care shall be taken in the selection and installation of the equipment to prevent long term deterioration due to these conditions.

- 1.8.7. Equipment shall be fully capable of withstanding variations of temperature arising under working conditions without distortion or deterioration, or the setting up of detrimental stress in any part, and also without affecting the suitability of the various parts with which they have to perform.
- 1.8.8. Unless otherwise stated all equipment shall be capable of operation in humidity conditions of 50% R.H. at 30 degrees Centigrade indoors. Equipment for use outdoors shall be capable of operating at 100% R.H. at 40 degrees Centigrade.
- 1.8.9. The Contractor shall check the altitude in every area and shall ensure that all equipment selected is capable of operation without deterioration at the prevailing altitude (generally less than 100m).
- 1.8.10. Equipment intended for use outdoors shall not be subject to deterioration due to ultra violet radiation.
- 1.8.11. Equipment shall not, as far as possible, offer a source of oxygen or other biogenic elements to micro-organisms. The presence of anaerobic earth bacteria, mould fungus or enzymes shall not result in the degradation of material. The equipment shall not contain materials or compounds that offer sustenance that attract vermin.
- 1.8.12. Equipment using or containing water shall be designed so as to prevent the breeding of Legionella bacteria. Wherever necessary, water shall be treated chemically for the suppression of Legionella bacteria.

1.9. Finishes

- 1.9.1. Generally, the finish and colour normally applied to the equipment by the manufacturer shall be used. Where a choice exists and no specific finish is stated in the particular specification, it shall be the responsibility of the Contractor to select the most appropriate finish to suit the application. Where it is necessary for aesthetic or other reasons, for a special colour or finish to be used, this shall be detailed in the particular specification. The Contractor shall provide the Engineer with full details of the proposed finish for each item of equipment prior to ordering.
- 1.9.2. On occasion, special situations may occur which cannot be accommodated within the normal paint or galvanised finishes commonly used for equipment. In these instances special finishes may be required, for example, extra thick galvanised finish, stainless steel finish, special plated finish, etc. The Contractor shall assess each of these special situations on its merits and propose a suitable solution to meet the requirements of the situation.
- 1.9.3. Where the Contractor uses equipment having a galvanised finish this shall be of a type that is galvanised after all manufacturing operations have been completed. The galvanising process used shall conform to and provide the deposit thickness detailed in EN ISO 1461. Where galvanised equipment is subject to cutting, drilling, or other operations during installation, the Contractor shall ensure that it is either re-galvanised or provided with some other local finish to provide equivalent protection.
- 1.9.4. Machined surfaces that are to be left bright after installation shall be suitably protected against detriment by means of an application of suitable grease, liquid film, etc.
- 1.9.5. Where equipment is purpose made for a particular installation it shall be provided with a finish suitable to the location. This finish shall preferably be applied at the place of manufacture and shall be applied to all faces of the Equipment before installation. The practice of installing equipment and then painting, leaving faces wholly or partially unprotected, is not acceptable.

1.10. Equipment Protection

- 1.10.1. The Contractor shall provide adequate and safe storage and protection for all materials, plant and equipment provided in this contract. All equipment shall be stored in accordance with the relevant British Standards advice.
- 1.10.2. All conduit is to be stored on purpose made racking giving adequate support to prevent bending and distortion. End caps will be used to protect conduit ends at all times prior to installation. Storage of conduits by laying on the ground will not be permitted.
- 1.10.3. All plant and equipment shall be so stored as to protect them from damage due to building work, and covered as appropriate.
- 1.10.4. Any machined or bright surfaces shall be protected by paint, tallow or grease if this has not been carried out by others or has been removed during transit. Upon completion surfaces so coated shall be cleaned and where applicable polished. Items that may be susceptible to corrosion shall be painted immediately after removal of the temporary protection.
- 1.10.5. The Contractor shall select, install or provide protection to equipment such that it is unaffected by the following conditions which can reasonably be foreseen for the equipment throughout the design life of the installation, taking into account any details set out in the particular specification.

1.10.6. Frost :

- 1.10.6.1. Where equipment is located outdoors, or indoors in unheated enclosures, or enclosures open to the atmosphere for ventilation, it may be subjected to damage, deterioration, or reduced performance due to frost deposits and the Contractor shall assess the risk in every case and select equipment either designed to operate in such conditions or provided with suitable protection to prevent damage, deterioration, or reduced performance of the equipment. When assessing the frost potential of any location the Contractor shall consider its exposure and associated wind chill effect.

1.10.7. Condensation :

- 1.10.7.1. Where equipment is subjected to temperature differences and humid atmospheric conditions, there is a risk of condensation forming within equipment which may cause deterioration of that equipment or its malfunction. In every case the Contractor shall assess the risk of condensation formation for all relevant points within the installation and shall take all necessary measures to protect equipment against the formation of condensation.
- 1.10.7.2. These measures may include, but not be limited to, ventilation, either natural or forced, removal of temperature differences by means of anti-condensation heaters or the use of equipment insulated sufficiently to allow self-heat to act as anti-condensation heating.
- 1.10.7.3. Wherever necessary, in particular where equipment passes from an area at one temperature to an area at a different temperature, condensation traps with drains shall be provided.

1.10.8. Damp :

- 1.10.8.1. Where equipment is to be installed outdoors or indoors on surfaces which are, or which may become, damp, it shall be constructed, finished, and installed to prevent deterioration. Wherever necessary, to ensure the design life of equipment, it shall be spaced off damp surfaces sufficiently to allow circulation of air between the equipment and the damp surface. When assessing the potential for dampness of internal surfaces, the Contractor shall consider the porosity of materials used for the building fabric, especially single skin walls exposed to the weather.

1.10.9. Water :

- 1.10.9.1. Where equipment is installed indoors or outdoors it may be subjected to contact with water under a number of circumstances. These vary in degree and intensity and include:
- 1.10.9.2. Permanent or periodic immersion in water
- 1.10.9.3. Casual spraying with water during rainfall
- 1.10.9.4. Casual or periodic spraying with water from a hose or pressure sprayer
- 1.10.9.5. Casual covering, either wholly or partially, with snow or ice
- 1.10.9.6. Any other means by which equipment may be exposed to water
- 1.10.9.7. The Contractor shall assess the degree of risk and shall ensure that the equipment chosen is designed and installed to operate in those conditions and prevent the ingress of water as necessary to prevent deterioration or malfunction.

1.10.10. Ground Water :

- 1.10.10.1. In some instances the exterior walls of premises may be below ground and the exterior surfaces of these walls may be subjected to ground water pressure either permanently or occasionally when weather or seasonal conditions prevail. In coastal areas this water may be tidal and may contain salt. Equipment mounted on, or passing through, such walls must be selected, installed or sealed such that they are not subject to deterioration by the exposure and such that they do not affect the ingress of water into the premises.
- 1.10.10.2. Where a waterproof render system has been applied to the internal or external surfaces of the premises, the Specialist Contractor who applied the render shall be consulted regarding fixings and penetrations to ensure that any guarantees are maintained.

1.10.11. Dust :

- 1.10.11.1. The Contractor shall evaluate the risk of dust penetration into the equipment for every location within an installation and shall select equipment adequately protected to prevent deterioration or malfunction by dust ingress for the design life of the installation.

1.10.12. Physical Contact :

1.10.12.1. The Contractor shall assess the risk of injury or electrical shock due to contact with energised parts for each location within an installation, and shall select equipment or provide protection to prevent contact, appropriate to the risk involved. Special careful consideration shall be given to areas where the general public have access, especially children, who it should be assumed will not appreciate the risks involved or read warning signs.

1.10.13. Mechanical damage :-

1.10.13.1. All equipment shall be protected against mechanical damage, whether accidental, anticipated or by vandalism. Protection shall be appropriate to each situation and may consist of, but not be limited to the following:

- Enclosure in metallic or other ducts or conduits
- covers of steel or other suitable material
- Total enclosure in a suitable housing
- Enclosure by a suitable guard rail
- Protective buffers

1.10.13.2. In certain instances, individual isolated items of equipment may require protection against mechanical damage, for example, lighting switches or socket outlets in exposed positions, and these shall be as outlined in the particular specification.

1.11. Handling of Equipment

- 1.11.1. All equipment shall be provided with suitable means for handling and placing into position. These shall include lifting points, eye bolts, sling positions or any other recognised method appropriate to the particular item of equipment.
- 1.11.2. The Contractor shall ensure that manufacturers indicate, by means of removable labels or similar marking, the slinging or lifting positions and the allowable weight that may be suspended at each lifting point to prevent incorrect handling on-site. For all items of equipment requiring the use of a mechanical lifting device, for example, a crane or fork lift truck to place them into position, the use of such a device shall be discussed with the Architect to ensure that the most appropriate lifting device is used. Where the use of such a device can be co-ordinated with other trades to minimise costs this shall be done.

1.12. Methods of Fixing

- 1.12.1. The Contractor shall allow for the design, supply and fixing of all necessary brackets, plugs and bolts on stanchions, walls, ceilings etc., where required to securely fasten conduit, switch boxes, saddles, distribution boards and other accessories and items of equipment in position. Such brackets must be of a type, make and pattern approved by the Engineer, who shall also approve the methods of fixing.
- 1.12.2. The boring or notching of structural steelwork, reinforced concrete beams, wood joists etc., for cable runs and/or fixings shall be kept to a minimum and must receive prior written approval from the Engineer.
- 1.12.3. All holes for plugs shall be cut or drilled by the Contractor, who must include for such works in his tender.
- 1.12.4. The Contractor must ensure that all conduits, luminaires, inserts etc., to be cast in-situ are plugged and securely fixed to prevent movement or ingress of grout etc.
- 1.12.5. Conduit, luminaires, and all other parts of the electrical installation shall not be fixed to any other adjacent services such as air ducts or sprinkler pipes, etc.
- 1.12.6. Equipment shall be installed using the following methods of fixing into each material, unless detailed otherwise in these specification documents, or as requested by the Engineer.
- 1.12.7. Timber :
- 1.12.7.1. Wood screws and nails shall only be used for small items; all pipework, ductwork trunking and cable tray supports shall not be secured in this manner, but shall use coach screws, coach bolts and bolts. All bolts shall be located at least 8 shank diameters apart. Pilot holes of the diameter and depth recommended by the manufacturer shall be drilled before fitting coach screws, and the complete thread of all coach screws shall be engaged into the timber.
- 1.12.7.2. Where the shank of a coach screw, coach bolt or bolt enters the timberwork, clearance shall be drilled for the appropriate length to prevent the timberwork splitting.
- 1.12.8. Brickwork, blockwork or concrete :

- 1.12.8.1. All fixings into brickwork blockwork or concrete shall be by woodscrew and plug, by grouted mild steel bolts or by an approved form of rawlbolt. When drilling, care shall be taken to avoid crumbling of the material around the hole. Holes in the face of a concrete beam shall be sufficiently distant from the lower edge so as to avoid the reinforcing rods, and to prevent flaking of the beam.

1.12.9. Steelwork :

- 1.12.9.1. Fixings to steelwork shall wherever possible be made using clamping systems which do not involve drilling the metalwork, but which provide a secure mounting. Other fixings shall be by means of setscrews or bolts and nuts of appropriate size. Each bolt or setscrew shall be fitted with a plain washer and a shake proof washer under the nut. Where it is not possible to fit a nut, a tapped hole shall be provided, the plain and shakeproof washers being fitted under the bolt head.

1.12.10. Foundation Bolts:

- 1.12.10.1. The Structural Frame Contractor shall provide and install all necessary foundation bolts, wall fixing bolts, rag bolts etc. for all apparatus and materials supplied under this contract.
- 1.12.10.2. Fixings to light gauge panels, of any material, which are inaccessible at the back shall be by means of shake-proof self-tapping screws or by spring or gravity toggles.
- 1.12.10.3. Explosive powered fastening systems shall only be used in steelwork thicker than 5mm and for shear load applications. The manufacturer's safety instructions shall be fully observed.
- 1.12.10.4. The size of the bolt or screw used must be the largest permitted by the diameter of the hole in the equipment to be fixed. All bolt or screw holes provided in equipment shall be used and each fixing must be secure. Countersunk heads shall be used where countersunk holes are provided.
- 1.12.10.5. The Contractor shall ensure that all fixings are chosen to suit the environment in which they are to operate and that deterioration due to chemical or electrolytic action does not occur. All screws and bolts shall be sheradised, with the exception of those used for sanitary ware which shall be stainless steel.
- 1.12.10.6. No fixings shall be made to structural elements without the approval of the Engineer. The Contractor shall provide the Engineer with a schedule, to be passed to the Structural Engineer, indicating all proposed fixings, which are subject to a point load in excess of 1kg. The schedule shall detail all items being fixed and the material being fixed into. The Engineer will comment within 10 days of receipt of this schedule, and no fixing of the items detailed shall commence until the methods have been approved.
- 1.12.10.7. Where the Contractor proposes to install equipment on chain or wire suspensions then care shall be taken to ensure that the wire and chain have adequate strength to support both the equipment and any forces that may be imposed upon it during installation and normal usage. Chains shall be of welded closed link construction conforming to BS 6405 and shall generally have 40 links per metre unless the specific location requires the number of links to be different. Chain shall generally be galvanised unless an alternative plated finish is required to suit particular environmental conditions. Wire shall be galvanised and shall comply with BS 183 and shall generally be of the multi-strand type.
- 1.12.10.8. Wire and chain shall be attached to Equipment by means of closed hook type suspensions or eye-bolts as appropriate which shall be manufactured from iron and steel. Soft alloy devices shall not be used. Suspensions shall be galvanised or paint finished according to the location. The chosen method will ensure the same carrying capacity as the wire or chain. Where it is necessary to form loops in wire for attachment to Equipment or the point of suspension this shall be achieved by means of suitable galvanised loop formers and clamps. Clamps may be of the bolted type or of the compression type and a double clamp shall be employed in every case for security.

2. LOW VOLTAGE SWITCHGEAR

2.1. General

- 2.1.1. All low voltage switch panels shall be factory-built assemblies, in compliance with BS EN 60439 with components in compliance with all relevant British Standards.
- 2.1.2. The switchboard shall be designed and manufactured to provide, with recommended maintenance, a working life of 25 years.
- 2.1.3. Unless detailed otherwise, low voltage switchgear shall be naturally air-vented and suitable for operation in ambient temperatures between -5 deg. C and 40 deg. C with a relative humidity up to 90%. IP43 for indoor installation in accordance with BS EN 60529:1992+A2:2013. The normal supply voltage shall be 400V, 3 phase 50Hz.
- 2.1.4. The particular specification accompanying this document shall override any conflicting requirements in this general specification.

2.2. Switch Panel Construction

- 2.2.1. Main low voltage electrical distribution switchgear shall be of the factory built assembly type and rigidly constructed of folded steel sheet not less than 2mm thick or constructed on a modular basis. Additional supports shall be provided within the panel where required to support heavy items of equipment, instruments etc. Sheet steel shall be electro-zinc coated to a minimal thickness of 0.009mm and chromate washed.
- 2.2.2. Fixing and fastenings used in the assembly of sheet steel fabrications shall be treated to prevent corrosion. All access doors and removable covers shall not be manufactured in sheet steel less than 1.5mm thick and be sufficiently rigid to avoid distortion. Tightening of retaining bolts, shall not make any sealing ineffective. External surfaces shall be smooth to avoid collection of dust and to facilitate cleaning.
- 2.2.3. Where a glazed door is to be utilised it shall have a Class 0 surface spread of flame complying with BS 476.
- 2.2.4. The overall height, excluding cable boxes shall not exceed 2.2 metres. Operating handles and locking devices shall be located within the limits of 450mm and 1880mm above floor level. The panels shall be form a dust and damp proof enclosure as classification IP43 with suitable gaskets provided round the doors and any removable covers, unless any other form of separation is directed within the requirements of the particular specification.
- 2.2.5. Paint furnishings for all steel for use indoors shall have two coats of rustproof primer, then filled as necessary, and flattened to a smooth finish, then two undercoats and the final finish being two coats of epoxy resin paint; the final coat drying to a hard semi-gloss surface. External colours shall be to the approval of the Engineer.
- 2.2.6. All bright machined parts shall have a protective treatment applied by the manufacturer before despatch and this treatment shall be kept intact up to the time of handover unless it has to be removed for installation. If the surface is then exposed after installation the Contractor shall apply a further protective coating in accordance with the Manufacturers requirements.
- 2.2.7. All removable panels are to have provision for thermographic surveys to be undertaken whilst the panel remains energised. Each removable panel that covers terminations and connections which would require a thermographic surveying are to have an infrared windows or punched (vented) clear plastic covers installed to allow visual and thermographic surveys without compromising the form of the panel
- 2.2.8. Any fixing screws required for removable panels shall be of the captive type, chrome plated and, if not countersunk, shall be provided with plated washers. All panel corners shall be radiused. All door furniture (e.g. locks, handles, fasteners, etc.) shall be chromium plated and doors shall be lockable. All components shall be readily accessible for maintenance with the doors open and any components shall be removable without removing the doors.
- 2.2.9. Removable plates shall be provided for bottom and top entry cabling to the switchgear, these plates shall be for terminating all incoming and outgoing cables. All plates shall be sealed against the ingress of dirt, dust and moisture.
- 2.2.10. Cables shall be easily accessible and marked to correspond with the panel wiring diagrams of external connections.
- 2.2.11. All plastics materials used in the switchboard shall have very low conductivity and shall be non-combustible, self-extinguishing, non-hygroscopic, and shall not produce smoke when heated to the point of decomposition.

2.2.12. Unless otherwise defined within the particular specification the switch panel shall be constructed to a minimum of Form 4A Type 3 (4B Type 7 for critical panels) to BS EN, with one of the following outgoing way configurations:

2.2.12.1. Air Circuit Breakers/Moulded Case Circuit Breakers:

- Where ACB's and MCCB's are specified within the particular specification they shall be of the type and ratings denoted on the low voltage schematic drawings and as defined elsewhere within this specification.
- Where the MCCB's form part of an internal cubicle they shall be arranged to be accessible from the front of the low voltage switch panel with suitably sized rotary handles, to ease operation.
- Insulated neutral links will be provided within each MCCB's cubicle - accessible from the front.
- Each ACB will be supplied with 4 N/O and 4 N/C 240V A/C auxiliary contacts, wired to a dedicated control wiring chamber.

2.2.12.2. Fused Switches and Isolators :

- All fuses and links shall be accessible from the front. Switches and isolators shall operate on all poles i.e.; the neutral link shall be switched, and shall be arranged to break last and make first, unless specified otherwise.
- All switchgear shall be capable of making, carrying and breaking the specified fault level. Switchgear shall be of utilisation category reference AC23 and be capable of carrying a maximum prospective short time withstand peak current of twice the rated fault current.
- All switchgear shall be suitable for uninterrupted duty and contacts shall be silver plated.
- Provision shall be made for locking the isolator in the off position with a standard padlock.
- All fuses shall be of the type and ratings indicated on the low voltage schematic drawing and as defined elsewhere within this specification.

2.2.12.3. Contactors:

- Where contactors are specified in the particular specification they shall be of the air break type, they shall be uninterrupted rating and contacts shall either be silver contacts or de-rated to allow for this duty. The contactors shall be category AC3 and have a no-load operating cycle of 1 million operations.
- All contactors shall be of the block type. Contacts shall be of the self-cleaning type and easily renewable. The design shall be such as to prevent welding in.
- All operating coils of contactors shall be able to operate on the control system voltage of the main low voltage switchgear.
- Each contactor shall be so screened from adjacent units and current carrying parts that it is possible to carry out maintenance work in complete safety, while other equipment in the switch panel remains alive on load.
- Each contactor will be supplied with 4 N/O and 4 N/C 240V AC rated auxiliary contacts.
- Means of isolation shall be provided to isolate all primary and secondary circuits to contactors, but means shall be provided to temporarily reinstate interlocks or other circuit interconnections with equipment which is required in service whilst the contactor is isolated.
- If the fault level for the main low voltage switch panel is higher than that specified for the making and breaking conditions within BS EN 60947 co-ordination of short circuit protective devices and contactors, the Manufacturer shall indicate the method and characteristics of achieving co-ordination.
- Where contactors are not located within switch panels or motor control centres they shall be installed within an enclosed steel enclosure with a lockable cover, dust proof seal and label giving the circuit reference, area served and voltage(s) contained.

2.2.12.4. Spare Module Positions :

- Where a spare module is indicated on the low voltage schematic drawings or as defined elsewhere within this specification, it shall be fully fitted complete with the designated switchgear, cabling and terminals suitable for the quoted rating.

2.3. Fault Levels

- 2.3.1. Unless otherwise stated within the particular specification all low voltage switch panels shall be ASTA certified to a minimum fault level of 50KA for 1 second (symmetrical, three phase). Busbar arrangements shall be ASTA certified.
- 2.3.2. Circuit breakers, switchgear, isolator's contactors, busbar and cable connections shall be suitable for operating at the above fault level.

2.4. Internal Busbars

- 2.4.1. Busbars and busbar connections shall be of high conductivity, hard drawn copper and shall be extendable at both ends and shall be air insulated and covered with shrinkable PVC sleeving. All busbars and connections shall be coloured in accordance with BS 3858 and BS 5559. Busbars shall be of constant cross section throughout their lengths with connections as short and straight as possible. Fully rated neutrals will run throughout.
- 2.4.2. Access to busbars and busbar connections shall be gained only by the removal of covers secured by bolts or screws. The covers shall be marked "Busbars" and give the following particulars on an engraved plastic label: -
 - Short time rating (seconds)
 - Fault MVA at 415 volts
 - Peak making current
- 2.4.3. Where an auxiliary voltage supply is required from busbars this shall be taken by HRC fuse links mounted on the busbars or fuse links connected by fully rated busbar connections.
- 2.4.4. All busbar supports will carry ASTA certification to the minimum fault level of 50KA for 1 second (symmetrical, three phase).

2.5. Internal Wiring

- 2.5.1. The main current carrying conductors of each main circuit from the incoming terminals to the outgoing terminals shall be capable of carrying, for one second without distress, the fault current.
- 2.5.2. The removal of insulation shall be carried out by the hot wire stripping methods.
- 2.5.3. All power wiring cables shall be LSF insulated cables to BS 6004 and shall be coloured in accordance with BS EN 60204 to indicate differing phases.
- 2.5.4. All power wiring shall be kept physically segregated from all other wiring and the working voltage shall be indicated on the fixed portion of the associated terminal boards.
- 2.5.5. The insulation of small wiring shall be 250 volts grade LSF to BS 6231:1990 for normal wiring and type A of BS 6231: 2006 for light current wiring. All small wiring shall be black, except where cables are on differing voltages in which instance, where specified, coloured bands shall be used in addition to the working voltage of the cables being indicated.
- 2.5.6. All small wiring shall be physically separated from all power wiring and the working voltage shall be indicated on the fixed portion of the associated terminal boards.
- 2.5.7. All small wiring shall not be less than 1.5 sq. mm section. The wiring shall be grouped according to the circuits involved. It shall be installed in insulated cleats of the limited compression type or non-rusting flexible tubing and shall be taken to terminal boards mounted not less than 225 mm from the floor of the termination compartment. Sharp tight bends shall be avoided and if it is necessary to bunch wiring, no bunch wiring shall contain more than 12 wires. Wires shall not be jointed or teed between terminal points. Fuses and links shall be provided to enable all circuits in a switchgear equipment/control panel to be isolated from the bus wires.

2.6. Cable Boxes and Glands

- 2.6.1. All cable boxes and glands for switch panels other than glands for MICC cable(s) shall be supplied as part of the switch panel.
- 2.6.2. All cable glands shall be in accordance with this specification and be suitable for the cables specified.
- 2.6.3. Where specified, cable boxes for lead or aluminium sheathed cables shall be fitted with universal tapered brass glands and combined armour and earthing clamps. Provision shall be made for earthing the body of each cable box. Where required single core cable boxes shall be provided with insulated cable glands.

- 2.6.4. The arrangement of the sweating sockets in 3 core cable boxes shall be such as to minimise the bending of cable cores. The cable boxes shall be designed and constructed to contain without leakage under the most arduous service and climatic conditions a bituminous compound.
- 2.6.5. Provision shall be made for expansion of the filling medium and the design shall be such as to prevent the formation of air spaces. Filling and drain plugs of ample size shall be provided. Cable boxes shall be mounted in an approved position and in such a manner as to ensure ease of jointing of cables.
- 2.6.6. Terminals shall be uniquely marked in a clear and permanent manner. Entry holes suitable for the reception of PVC, SWA and MICC cables shall be provided in the gland plates. Gland plates shall be removable and facilities for earthing the armoury of cables shall be adequately be provided.

2.7. Interlocks and Locking Arrangements

- 2.7.1. Interlocks
- 2.7.2. Interlocks shall be provided as required, positively to prevent:
 - Racking in a closed-circuit breaker or contactor.
 - Closing of a circuit breaker or contactor with the moving portion in an intermediate position.
 - The cover of a switch-fuse or fuse-switch or composite switch and fuse unit being opened with the switches closed.
 - The closing of switch fuse, fuse switch or composite switch and fuse units with the cover open.
 - The closing of switch fuse, fuse switch or composite switch and fuse units with the cover open.
- 2.7.2.1. Isolators and switches shall be mechanically interlocked with the cubicle door to prevent access to the mechanism unless the isolator is opened and conversely to prevent closure of the isolator or switch and the cubicle door open.
- 2.7.2.2. All mechanical interlocks shall be of the preventative type and shall be arranged to prevent mal-operation as close as practicable to the operating handle, key switches, castell interlocks and cover plates.
- 2.7.2.3. All electrical interlocks shall function so as to interrupt the operating supply and an approved system of interlocks shall be provided to cover hand operation of equipment which is normally electrically operated.
- 2.7.3. Locking Arrangements
 - 2.7.3.1. All padlocks shall be non-ferrous, of an approved type and size to suit the equipment. No lock shall be smaller than 25mm. The shackle holes in the equipment shall be large enough to permit easy insertion of the relevant padlock, but not so large as to allow excessive movements with the lock in position.
 - 2.7.3.2. A cabinet shall be provided in the main low voltage switch room for the accommodation of keys and padlocks when not in use.
 - 2.7.3.3. As a minimum 10 padlocks and keys will be provided.

2.8. Earthing

- 2.8.1. Earth bars shall be of copper and shall extend the full length of the switchgear and be rigidly supported at intervals of not more than 1m. The earth bar section shall be not less than 50mm x 6.25mm and shall be rated for the fault level at the panel's point of installation.
- 2.8.2. Provision shall be made at each end of earth bars for external connections. The various component parts of enclosures forming switchgear shall be effectively connected to its earth bar. Cable glands shall also be effectively connected to the earth bar.
- 2.8.3. Particular care shall be taken to ensure that:
 - 2.8.3.1. The frame of draw-out circuit breakers shall be connected to the earth bar through a substantial plug type contact and that the plug shall be long enough to allow the busbar shutters to close before breaking contact.
 - 2.8.3.2. The cases of instruments, relays and meters shall be connected to the earth bar by means of conductors of not less than 2.5 sq. mm section.
 - 2.8.3.3. Where equipment is separately mounted, each shall be provided with a 12mm diameter earthing terminal.
 - 2.8.3.4. The star point of each group of current transformer secondary connections shall have a separate earthing link in an accessible position. This position shall be at the relay panel except in the case of metering current transformers which shall be earthed at the switchgear.

- 2.8.3.5. All access doors shall be connected to the earth bar by means of conductors of not less than 2.5 sq. mm section connected to an earthing stud terminal fixed firmly to each door. Access door hinges shall not be relied upon for earth continuity.
- 2.8.3.6. The entire frame of the panel is effectively earthed, fortuitous earthing is not acceptable.

2.9. Labelling

- 2.9.1. The completed switchboard shall be provided with a label giving full manufacturers and electrical details.
- 2.9.2. The exterior of all removable covers that give access to energised parts within the switchboard shall be provided with safety signs complying with BS 5378 to warn of the voltage hazard present.
- 2.9.3. Each outgoing and incoming circuit shall be clearly labelled in English and any other specified language to indicate the circuit controlled, and the size or settings of the protective device. Labels shall include black lettering, minimum height 5mm on a white background for warning labels.
- 2.9.4. All labels shall be screwed, not glued or fixed by the use of rivets. All labels both inside and outside the switch panel shall be manufactured from Traffolyte. The Engineers approval to all wording shall be obtained before manufacture commences.
- 2.9.5. All wiring within the panel will be uniquely numbered at both ends using non-flammable slip on cable markers.

2.10. Instrumentation

- 2.10.1. Instruments shall be "Industrial" grade and be of approved manufacture. The instruments shall be of robust construction and enclosed in dust-tight metal cases, arranged for flush mounting and securely fixed by an approved method.
- 2.10.2. Instruments shall be confined to a single area of the switchboard, which shall be no longer than necessary, and such that no meter is higher than 1800mm above finished floor level, and selector switches and other operable devices no higher than 1500mm above finished floor level.
- 2.10.3. All instrument scales shall be in accordance with BS 3693:1992.
- 2.10.4. Instruments shall have a 240 degree movement and the maximum possible length of scale with a minimum dial size of 100mm. Scales shall be white, cleanly divided and indelibly marked in black. Pointers shall have a clear outline and the markings of the dial shall be subject to approval. Ammeters indicating motor current shall be of the compressed scale type. All ammeters shall have the normal full load current of their associated circuits marked by means of a red line.
- 2.10.5. The rims of instruments shall have a uniform high grade matt black finish or a particular colour to BS 4800:2011, whichever is required by the Engineer. Rims of other accessories shall preferably be chromium plated.
- 2.10.6. AC instruments shall be of the moving iron type with CT's where necessary and DC instruments shall be moving coil supplied complete with associated shunts. Directly connected ammeters shall be limited to circuits of below 40A full load.
- 2.10.7. Ammeters shall be capable of carrying rated current continuously without overheating, be suitable for operation without damage in association with the direct on-line starting of motors and shall withstand the passage of fault currents until operation of the main current protective device.
- 2.10.8. Ammeter scaling shall be such that normal full load current gives approximately 75% full scale deflection. All instruments shall be back-connected and all metal cases shall be earthed. Approved means shall be provided for zero adjustments of the instruments without dismantling. All remote ammeters for AC circuits shall be current transformer operated.
- 2.10.9. The main L.V switch panel shall be provided with the following instrumentation unless otherwise stated within the particular specification:
 - Volt meters. (L-L & L-N).
 - Ammeter. (L1, L2, L3).
 - Maximum demand metering.
 - Power factor metering.
 - Earth Leakage Ammeter.
 - Supply Healthy Lamps.
- 2.10.10. It should be noted that where two or more incoming supplies are present duplication of the above will be necessary.

- 2.10.11. The above instrumentation is to be mounted on the main L.V switch panel. All necessary CTs, potential fuses etc. required for the above instrumentation, are to be included in a purpose built link box(s) enclosure located within the main L.V switch panel.
- 2.10.12. Indicator lamps shall be of the same type throughout, and shall be provided with test facilities. Lens colour shall be in accordance with BS EN 60073:1993.
- 2.10.13. Indicator lamps shall be renewable with the module door closed.
- 2.10.14. Digital instruments shall be supported with manufactures detail that confirms the instruments error margin does not exceed a percentage error greater than ± 0.5 percent.
- 2.10.15. Digital instruments shall not be limited to only measure sinusoidal waveforms and shall be able to measure the energy profile's true RMS (TRMS) and frequency.

2.11. Voltage Transformers

- 2.11.1. Voltage Transformers (VTs) for use with control circuits shall comply with BS 3535, Section F. They shall be single phase having the primary and secondary voltages detailed upon the drawings.
- 2.11.2. Voltage transformers connected between phases shall have fuses fitted in both input connections.
- 2.11.3. Output connections shall be fitted with a fuse in one pole and a solid link in the other. The non-fused output terminal shall be connected to earth through a removable bolted link.

2.12. Current Transformers

- 2.12.1. Current transformers (CTs) shall be of the bar primary, ring type manufactured and tested in accordance with the requirements of BS 7626:1993. They shall be installed on the fixed portion of the equipment, and except in the case of busbar coupling and sectioning equipment on the switched side of the circuit breaker remote from the busbars. Bar type primary windings shall be used wherever possible.
- 2.12.2. Current transformers shall be constructed so as to withstand safely the mechanical and thermal stresses caused by a short circuit equal to the full short circuit rating of the associated switchgear. The secondary windings of each set of current transformers shall be earthed at one point only, connected through a removable link placed in an approved position.
- 2.12.3. Current transformers shall be capable of withstanding for one minute without damage, the effects of an accidental open circuit in the secondary circuit with full load in the primary.
- 2.12.4. The method of securing current transformers in position shall be such that no undue pressure is exerted on the windings. All connections from secondary windings shall be brought out and taken by means of separate insulated leads to the terminal board, and shall be securely braced and so arranged to prevent accidental contact with main connections which may be caused by displacement or the breaking of the leads. The terminal board shall be of the stud type having short circuit links which can be connected with power on.
- 2.12.5. The Contractor shall state the accuracy, capacity and ratio of the transformers and shall guarantee that the transformers are suitable for the particular duty with which they are associated.
- 2.12.6. Where equipment is to be supplied under this contract forms part of a composite scheme, the Contractor will be required to co-operate fully with the suppliers of associated equipment to ensure correct operation of the scheme.
- 2.12.7. Protective current transformers shall maintain their ratio to ensure stability of protective systems under through fault. Magnetisation curves and type test certificates shall be submitted when requested by the Engineer.
- 2.12.8. The polarity of the primary and secondary windings of each transformer shall be clearly indicated in an approved manner and, in addition, labels shall be fitted to indicate the duty of each transformer, and to warn of high voltage when the C.T secondary is disconnected, in an accessible position.

2.13. Control Fuses

- 2.13.1. Where a control circuit is supplied directly from a current transformer, main busbar or otherwise, it shall be protected by means of control MCB or HRC power fuse(s) as in power fuses as stated elsewhere within this specification. In general, control fuse bases and carriers, of the fully shrouded type having cartridge fuses will be accepted subject to the approval of the Engineer.
- 2.13.2. The fuse bases and carriers shall be coloured as follows in accordance with clause 42 of BS 162:1978 and with BS EN IEC 61439-1
 - 5 amp - Black
 - 15 amp - Light Green
 - Link - White

2.13.3. In general control fuses will be located in a dedicated section of the panel.

2.14. Controls

2.14.1. Control Relays

- 2.14.1.1. Control relays shall be capable of five million operations and shall preferably be totally enclosed, plug in type with mechanical restraint. If open types are used they shall have coils and contacts which are replaceable without disturbing other wiring.
- 2.14.1.2. Rating of coils and contacts shall be suitable for the particular application chosen. In addition to the contract requirements, relays shall be provided with at least one spare normally open and normally closed contact.

2.15. Surge Diverters

- 2.15.1. The main LV switch panel is to be fitted with a set of non-linear resistor type surge diverters. These shall comply and be installed as defined in BS 2914 for cubicle type switch boards. These units are to be mounted integrally to the panel.
- 2.15.2. The surge diverters will be as defined below and in addition must be adequately rated for the fault level at their point of installation.
- 2.15.3. Surge diverters shall be selected to provide protection to the installation and in particular to MICS cables and computer services, from the following:
 - The effects of lightning strikes either on the company's premises or on the public power supply network;
 - The effects of switching surges generated by switching on the public power supply network external to the company's premises;
 - The effects of switching surges generated within the company's premises, for example, by large motor or lighting loads.
- 2.15.4. The Contractor shall ensure that the surge diverters are chosen to suit the conditions pertaining to the particular installation, but minimum criteria as set out below shall apply in all cases:
 - Standard nominal discharge current shall not be less than 2500 Amperes when measured with an 8/20 wave shape in accordance with BS 923.
 - Peak discharge current measured with an 8/20 wave shape in accordance with BS 923 shall not be less than 20,000 Amperes.
 - Leakage current phase to earth shall not exceed 50 micro-amperes.
 - Maximum transient voltage let-through throughout the application of the 8/20 wave shape shall not exceed 650 volts.
- 2.15.5. The surge diverters shall be connected to the company's installation as close as possible to the outgoing terminals of the main low voltage switch located on the main low voltage switchboard.
- 2.15.6. Connection shall be made by means of a separate moulded case circuit breaker or fuse-switch, as appropriate to the type of switchboard, to afford protection and provide isolation of the surge diverters for insulation resistance testing of the installation and allow isolation of the surge diverters in the event of malfunction.
- 2.15.7. The moulded case circuit breakers or fuses shall be selected so as to allow the surge diverters to function correctly and provide the correct protection.
- 2.15.8. The method of connection of the surge diverters shall not reduce the fault rating of the switchboard.

2.16. Special Tools

2.16.1. Special tools, operating handles or equipment for installation, maintenance or operation of the equipment, are to be provided as detailed below:-

- 1 Operating Handle for each Air Circuit Breaker

2.17. Spares

2.17.1. The Contractor is to provide all safety equipment/spares necessary for the safe operation of the switch panel.

2.17.2. These are to include but not be limited to the following:

- 1no. complete set of screwdrivers
- 1no. complete set of spanners
- 1no. complete set of Allen keys
- 1no. switchgear manufacturer approved test kit for testing all protection setting on MCCB's and ACB's.
- 1no. Motor Drive Unit for each type of motor driven MCCB/ACB.
- 1no. Contactor coil for each type installed.
- 1no. Ammeter
- 1no. Voltmeter
- 1no. Current transformer of each type used.
- 1no. Selector switch for each ammeter selector switch installed.
- 1no. Selector switch for each voltmeter selector switch installed.
- Fuses as detailed in section 11.0.
- 1no. lockable steel wall mounted box for housing the above, items 1-12 plus any other spares recommended by the manufacturer.
- 2no. Spare keys for the lockable steel cabinet.
- Safety rubber mats for complete length of switch panels to BS 921:1976 (1987) tested to 15kV.

2.18. Torque Setting

2.18.1. All bolted busbar connections will be tightened using a certified torque wrench, to pre-specified values commensurate with the system design fault level.

2.18.2. Once torqued, all nuts/bolts will be marked with a coloured ink marker, or other permanent marker.

2.18.3. A certificate of calibration will be submitted stating the accuracy and date of the last test completed on the torque wrench. Each torque wrench will have a unique serial number.

2.18.4. The above will be actioned on all primary and secondary busbars, including those connecting to ACB's and MCCB's and all incoming main and generator cables, together with all outgoing circuit cable connections..

2.19. Testing and Commissioning

2.19.1. The manufacturer shall provide routine and type test certificates for each type and rating of switchgear. The tests shall be those listed in the relevant standards.

2.19.2. Routine tests shall be carried out on all switchgear/components as specified in the relevant standards. These tests shall include:

- Power, frequency and voltage tests on the switch panel.
- Voltage tests on the control and auxiliary circuits.
- Measurement of the resistances of the main circuit.
- Mechanical operating tests.
- Test of auxiliary equipment, including interlocks and control devices.
- Verification of the correct wiring and phase rotation.
- In addition the manufacturer shall carry out primary and secondary injection tests to prove the correct operating of the protection relays.
- Where insulation tests are conducted they will be completed with the switch panel fully assembled and all switches in the closed position.
- Insulation and dielectric tests between all phases, all phases to neutral, all phases to earth and neutral to earth.

- Testing of the interlocking, inter-tripping and control wiring system - illustrating that all parts function as specified.

- 2.19.3. The manufacturer will provide the Engineer with a minimum of 4 weeks prior to commencement of testing.
- 2.19.4. All costs associated with the above will be included in the Contractor's tender return.

2.20. Commissioning

- 2.20.1. The Contractor shall make two temporary manuals with provisional Record Drawings and preliminary performance data available at commencement of commissioning to enable personnel to familiarize themselves with the final manuals, complete with temporary insertions for items which cannot be finalised until the Works are commissioned and performance tested.
- 2.20.2. The Contractor shall allow for the submission of all inspection, test and approval certificates as required within these documents. Copies are to be issued to the Engineer.
- 2.20.3. In addition the Contractor will provide copies of all calibration certificates for equipment used for testing the switch panel.
- 2.20.4. The manufacturer will allow for all necessary on site attendance to ensure the correct operation of the equipment. The Contractor will make an allowance for on-site instruction (to the Engineers satisfaction) as to the operation of all items of the switch panel to the Employers operatives and representatives.
- 2.20.5. The FAT testing regime shall include as a minimum the following:

2.20.5.1. Visual Inspection

- Cubicle construction
- Earth tags
- Bus bar ratings / sizes
- Device ratings match drawings
- Clearances of bus bars
- Inspection of bolts (inc 5% random torque settings) all others marked as torqued
- Phase identification
- CT ratings and settings
- Cable entry & Access
- Thermographic screens
- Labelling
- BMS connections

2.20.5.2. Functional testing

- Phase sequences across whole panel
- Flash (dielectric) tests
- Megger tests
- Meters operating
- ACB function (charging, operation)
- Settings check
- Secondary Injection testing for rated current (instantaneous, short term, long term etc)
- Restricted earth fault test.

3. LOW VOLTAGE DISTRIBUTION BOARDS

3.1. General

- 3.1.1. All distribution boards shall be of the sizes and types specified and shall be fitted with air circuit breakers, moulded case circuit breakers, miniature circuit breakers, residual current devices or HRC fuses as detailed in the particular specification or drawings. Where distribution boards are specified to be complete with an isolator and/or restricted current circuit breaker, they shall be integral within the distribution board enclosure. Isolators shall be double pole for SP & N distribution boards and triple pole with neutral link for TP & N distribution boards.

3.2. Standards

- BS EN 60947:2021
- BS159:1992 Busbars
- BS5486:1990
- BS EN 60439:1990
- BSEN 60898
- BSEN 60947
- BSEN 60947-2

3.3. Distribution Board Construction

- 3.3.1. The enclosures shall comprise a case and door(s) of sheet metal. The type of construction shall be damp and dust protected to classification IP31 minimum. Doors shall be provided with quick release hinges and fitted with cylinder key lock.
- 3.3.2. All bright machined parts shall have a protective treatment applied by the manufacturer before despatch and this treatment is to be kept intact up to the time of handover unless it has to be removed for installation. If the surface is then exposed after installation the Contractor shall apply a further protective coating in accordance with the manufacturer's requirements.
- 3.3.3. Unless otherwise defined within the particular specification all Distribution Boards shall be surface-mounting and adjustable for flush mounting, with the aid of a kit or other means.
- 3.3.4. The enclosure and door shall be made of electro-zinc coated sheet steel with an epoxy powder finish and high protection against corrosion (2000 hours salt spray).
- 3.3.5. The enclosure shall be fully factory-assembled into a single rigid structure and of sufficient size providing minimum gutter space on all sides.
- 3.3.6. Busbars shall be rigidly mounted in the same position on all poles relative to their banks of fuses or MCB's and fully shrouded to enable spare ways to be wired whilst the board is live. Busbars shall be copper to BS 159:1992 and BS EN IEC 61439-1:2021 and BS EN 60439:1990 (IEC 439).
- 3.3.7. All incoming terminals shall be fully shrouded and of the pressure clamp or socket type.
- 3.3.8. Renewable labels in the form of cards in a transparent envelope shall be provided within the enclosure for recording the following information for each circuit :
- Circuit Designation
 - Cable Size
 - Circuit Rating
- 3.3.9. Each distribution board shall be provided with an identification label, which shall be permanently screw fixed to the front.
- 3.3.10. All such external labels shall be white traffolyte with engraved black letters.
- 3.3.11. Neutral and earth terminals shall be provided, one for each outgoing phase way, in positions respective to their phase terminals. All neutral terminals shall be fully shrouded.
- 3.3.12. Where required, distribution boards specified with a clean earth, will be supplied with a fully insulated clean earth bar with one terminal for each outgoing phase way.
- 3.3.13. Distribution boards will be of the following types:
- 3.3.13.1. MCCB Distribution Boards:
- The boards shall be designed to accept current-limiting moulded case circuit breakers from 63A to 225A and shall be rated for the intended voltage (240/415V ac 50 Hz). The boards shall conform to

BS5486 Part 12:1989 and BS5486 part 1:1990 and have a 250A MCCB incoming device fitted as standard, unless defined elsewhere.

3.3.13.2. MCB Distribution Boards

- The boards shall be designed to accept current limiting miniature circuit breakers from 1A to 100A and shall be rated for the intended voltage (240/415V ac 50Hz).
- The boards shall conform to BSEN 60439-1: 1994 (distribution boards) and BS EN IEC 61439-1:2021 (consumer units).

3.4. Interiors

- 3.4.1. All interiors, with the exception of the circuit breaker and incoming devices, shall be completely factory-assembled.
- 3.4.2. Moulded case circuit breaker distribution boards shall have busbars of copper construction, rated to a minimum of 250A and shall be of the fully shrouded type.
- 3.4.3. Miniature circuit breaker distribution boards shall have busbars of copper construction, rated to a minimum of 100A, and shall be of shrouded type.
- 3.4.4. The busbar rating will be suitable for the fault level at its point of installation.
- 3.4.5. An integral disconnecting device shall be fitted to comply with BS 7671 Latest Edition IEE Wiring Regulations, suitable for isolation and shall be incorporated in the connection to every outgoing way.
- 3.4.6. If required, the outgoing circuit breakers shall be fitted with add-on tripping or signalling devices. This shall be possible either on installation or retrospectively, with no special tools being required.
- 3.4.7. There shall be a choice of incomer between direct connection, switch disconnecter and residual current device. It shall be possible to equip the boards with a moulded case incoming circuit breaker of up to 225A. An extension box shall be available for use with the MCCB.
- 3.4.8. The range of distribution boards shall include a split-load board and one which can accept both distribution and control devices, enabling complete installations, including control devices, to be sourced from one supplier.
- 3.4.9. A range of add-on extension boxes shall be available, to enable control devices or up to 18 SP outgoing ways to be associated with the standard TP & N distribution board.
- 3.4.10. The range of distribution boards shall be of a modular design, such that several boards may be conveniently group-mounted for large or awkward installations.

3.5. Additional Requirements for MCCB Distribution Boards

3.5.1. Pan Assembly

- 3.5.1.1. All components and sub-assemblies shall be mounted on a strong chassis, consisting of 1.6mm-thick, zinc coated and passivated, folded sheet steel, with a Prisma Beige epoxy powder coated paint finish or as defined in the design specification.
- 3.5.1.2. Busbars shall be made of hard-drawn, high conductivity copper. Busbars and associated connections are to be ASTA certified at 35kA for one second (minimum).
- 3.5.1.3. Fully rated neutral busbars shall be provided, each with a detachable link compliant with BS7671 18th Edition of IEE Wiring Regulations. Busbar supports shall be designed to withstand the maximum mechanical stresses under the fault conditions detailed.

3.5.2. Ambient operating temperature

- 3.5.2.1. MCCB distribution boards shall be suitable for operation at an ambient air temperature of 40 deg C, without any de-rating.

3.5.3. Identification

- 3.5.3.1. The following labelling shall apply to all distribution boards:

- Distinct labelling shall identify neutral and earth bar.
- Colour-coded phase labels shall identify supply and feed phases.
- Positive Contact Indication labels shall identify status of MCCB's and switch disconnectors.
- An electrical hazard label shall be visible upon removal of the front cover.
- Combined installation instructions and circuit record chart shall be provided with each board.

3.5.4. Electrical characteristics

- Rated insulation voltage: 500V AC
- Maximum rated current of busbars: 630800A
- Rated minimum short-time withstand current of busbars:
- 3-phase - 35.5kA for 1 second; 75kA peak phase and neutral - 22kA for 1 second; 46kA peak
- Busbar ratings must match the rating of the respective panel rating

3.5.5. Incoming devices

3.5.5.1. The MCCB distribution boards shall be arranged to accept incoming supplies rated up to 800A (1600A potentially) via:

- Switch Disconnector
- Moulded case circuit breaker of appropriate rating

3.5.6. Outgoing devices

3.5.6.1. The boards shall be arranged to accept outgoing moulded case circuit breakers of the following maximum ratings:

- Power distribution board: 1600A, 1- and 3-pole
- Panelboard: 100A, 1-pole and 1600A, 3-pole

3.5.6.2. All breakers, both incoming and outgoing, shall be manufactured to BS EN 60947: 2021 and be in accordance with general moulded case circuit breaker specification, dealt with elsewhere in this specification.

3.5.7. Instrumentation

- All boards will be supplied with a factory fitted ammeter (L1, L2, L3) and voltmeter (L1, L2, L3, L1N, L2N, L3N).
- All distribution boards shall be supplied with a factory tested check meter.

4. PROTECTIVE DEVICES

4.1. General

4.1.1. The Contractor shall ensure that where protective devices are specified within the particular specification and elsewhere within this specification they meet the following standards and configuration requirements.

4.2. Standards

- BS EN 60947: Air Circuit Breakers
- BS EN 60947: Moulded Case Circuit Breakers
- BS EN 60898: Miniature Circuit Breakers.
- BS 88, BS 1361, BS 3036, BS 1362: Cartridge Fuses.
- BS EN 61008 & BS EN 61009: Residual current operated circuit breakers.

4.3. Air Circuit Breakers

4.3.1. General

- Air circuit breakers shall comply with BS EN 60947: 2021. The breaking capacities of air circuit breakers shall be at least equal to the prospective fault level at the point of the distribution system where the air circuit breaker is installed. Breaking Capacity Performance certificates shall be available for Category of Duty (P2) to the aforementioned standards and certified by ASTA (Association of Short Circuit Testing Authorities).
- The circuit breaker shall be designed with a quick-make-quick-break contact arrangement, with the speed of operation being independent of the operator and the operating mechanism trip-free, to prevent the contacts being held closed in the event of a fault such as a short circuit or over load.
- Air circuit breakers shall be able to be reverse-fed without reduction in performance. They shall have a rated operation voltage of 660V AC (50/60Hz). All air circuit breakers shall be fully tropicalised (T2) as standard.

4.3.2. Construction

- All air circuit breakers shall be designed for minimal maintenance. They shall be available in fixed and draw-out models and in 3-pole and 4-pole versions. On the 4-pole version, the neutral pole shall have the same current rating as the other poles, from 800A up to 4000A, and N/2 from 5000A to 63000A.
- All air circuit breakers main contacts shall be housed in reinforced polyester casing and provide double insulation from the operator and breaker front face, yet shall still be fully maintainable. Free tripping with priority opening shall be provided on all poles (common operating shaft).

4.3.3. Operating Mechanism

- 4.3.3.1. The operating mechanism shall be of the O-C-O stored energy spring type, with a closing time less than or equal to 60 milliseconds.
- 4.3.3.2. Air circuit breakers shall be opened and closed via a stored energy mechanism :-
 - AS STANDARD: hand-charged spring, where the springs are charged only by hand
 - OPTIONALLY: motor-charged spring, where the springs are automatically charged by electric motor. The maximum time to charge the springs shall not exceed four seconds. It shall be possible to manually override and charge spring by hand, should the need arise.
 - It shall also be easy to convert from hand to motor on site, without the need of special tools.

4.3.4. Main Contacts

4.3.5. General

- Contacts shall be designed to be maintenance-free in normal usage. The contact assembly shall automatically show the need for the contact to be replaced, through an integral mechanical indicator.

4.3.5.1. Positive Contact Indication

- A mechanical indicator shall be placed on the front face of the air circuit breaker and linked to the main contact assembly in such a manner as to positively indicate the contact status. It shall only be possible for "OFF" to be indicated when all the contacts are parted and isolated by the required distance.

4.3.6. Arc Chutes

- Arc chutes shall be common on the whole range and removable on site, to allow their condition to be checked.

4.3.7. Drawout Mechanism

4.3.7.1. General

- Three definite positions of the draw-out portion within the air circuit breaker assembly shall be possible:
- Connected Position - All main and auxiliary circuits engaged.
- Test Position - All main circuit disconnected; auxiliary circuits engaged.
- Withdrawn - Remove ACB carriage No contacts made.

4.3.7.2. Safety Requirements

- A door interlock shall be provided so that it shall not be possible to open the door until the air circuit breaker draw-out portion is in the disconnected position.
- Independent, insulated safety shutters shall be provided over the incoming and outgoing main circuits. A mal-insertion system shall be provided, to prevent insertion of a circuit breaker draw-out portion of a higher current rating than that of the fixed portion.
- The racking handle shall be stowed on the air circuit breaker so that it is accessible from the front and does not affect the door interlocking.

4.3.8. Electrical Auxiliaries

- All electrical auxiliaries, including the motor spring charging mechanism, shall be fully field-adaptable without any adjustment or the necessity for special tools.
- They shall be fitted into a compartment which, under normally loaded conditions, has no metal work energised from the main poles exposed. Any adaption carried out thus shall not change the profile of the breaker. It shall be possible to connect all auxiliary wiring from the front face of the air circuit breaker. This wiring shall be taken through a set of disconnecting contacts, so that all auxiliary wiring is automatically disconnected in the isolated position. All accessories shall be common throughout the full range.
- As a minimum all air circuit breakers shall be supplied with 2 normally open and 2 normally closed, contacts in addition to those detailed within the particular specification.

4.3.9. Mechanical Indicators

4.3.9.1. Mechanical indicators shall be provided but not limited to the following:

- | | |
|---|--------------|
| • Main Contacts closed, | "ON" |
| • Main contacts open, | "OFF" |
| • Springs | "CHARGED" |
| • Springs | "DISCHARGED" |
| • Circuit breaker in | "CONNECTED" |
| • Connected drawout positions only | |
| • Circuit breaker in "test" position (drawout only) | |
| • Circuit breaker in "disconnected" position (drawout disconnected positions only). | |

4.3.9.2. All indicators must be clearly visible.

4.3.10. Mechanical Interlocking

- 4.3.10.1. All draw-out air circuit breakers shall be completely mechanically interlocked to prevent the insertion or withdrawal of the breaker with the contacts closed, or out of sequence.
- 4.3.10.2. Ronis, Profalux, Castell, Low and Fletcher locks etc. (locks and keys to be supplied).
- 4.3.10.3. Breakers will have the facility to be interlocked together, either horizontally or vertically, by direct mechanical linkage.

4.3.11. Standardisation

- 4.3.11.1. A maximum of four different physical frame sizes will cover the whole range from 800A to 6300A, three- and four-pole.
- 4.3.11.2. All air circuit breakers up to 3200A shall be of the same physical dimensions, notwithstanding differences between three- and four pole versions. A negligible safety perimeter to earthed metal shall be a standard feature (draw-out version). Air circuit breakers shall be fully documented and the following literature shall be made available:
- Main manufactures catalogue
 - Installation Guide
 - Instruction Manual
 - Transparent Characteristic curves

4.3.11.3. All air circuit breakers shall be provided with protection devices, according to the following parameters:

4.3.12. General Requirements

- 4.3.12.1. The overcurrent relay shall be of the solid state type and be integrated as part of the circuit breaker. The current sensors necessary to detect the magnitude of current in the phases shall be located within the moving portion of the air circuit breakers, with the current rating visible from the rear.

4.3.13. General Specification

- Long-time Protection
- Adjustable from 0.4 to 1 times sensor rating.
- Short time protection

- Adjustable from 2 to 10 times setting made on the long-time protection time delay setting (where required) adjustable from instantaneous to 0.3 seconds.
- Instantaneous (where required)

4.3.14. Generator Set protection

- Long-time protection
- Adjustable from 0.4 to 1 times sensor rating
- Time delay adjustable from instantaneous to 0.3s
- instantaneous (where required)

4.3.15. Options

4.3.15.1. Without an increase in volume, it shall be possible to provide the following options:

- Ammeter - continuously displaying the highest phase current flowing through the circuit breaker and the indicating the phase in which that current is present. Selectable to display the current in any phase.

4.4. Moulded Case Circuit Breakers

4.4.1. General

- 4.4.1.1. All MCCB's shall comply with BS EN 60947 and be of the current-limiting design.
- 4.4.1.2. All MCCB's shall be designed for horizontal or upright mounting, without any adverse effect on electrical performance, and be suitable for reverse feeding.

4.4.2. Construction

- 4.4.2.1. The operating mechanisms shall be of the quick-make/quick-break type, with the speed of operating independent of the operator and mechanically trip-free from the operating handle, to prevent the contacts being held closed against a short circuit or overload condition. The operating mechanism shall be constructed to operate on all poles simultaneously in a multi-pole breaker, during opening, closing and tripping operations.
- 4.4.2.2. The circuit breakers shall be operated by a rotary handle or motor mechanism, which will clearly indicate the three fundamental positions:
 - ON
 - OFF
 - TRIPPED
- 4.4.2.3. The breaking and extinction of the arc created during switching shall be achieved by means of non-welding contacts and arc chutes surrounding these contacts, with polyamide inserts to reduce arc quenching gas under short circuit conditions.
- 4.4.2.4. The circuit breaker shall be complete with Positive Contact Indication, which shall be maintained should the breaker be enclosed or fitted with any operating accessory, e.g. rotary handle or motor mechanism.
- 4.4.2.5. All circuit breakers shall be manufactured with double insulation of the front face, insulating the auxiliary compartments from the main power poles, thus allowing the installation of auxiliaries without full isolation of the unit.
- 4.4.2.6. All accessories and electrical auxiliaries such as shunt trips, under-voltage releases, auxiliary contacts, motor mechanisms, shall be manufactured in such a way as to allow easy installation, either at manufacturers' works or on site.
- 4.4.2.7. The current limiting MCCB's with very high breaking capacities shall be made of two parts:
 - A standard circuit breaker to break small and medium fault currents.
 - A current limiting block to break and limit large short circuit currents. This shall be of the electromechanical type (fuse free) and factory-fitted to the standard breaker.
- 4.4.2.8. All MCCB's will be suitably rated for the fault level at their point of installation.

4.4.3. Operation

- 4.4.3.1. For MCCB's up to and including 1600amps, each pole of the MCCB shall be provided with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. The thermal release shall be of the adjustable type and may be equipped with a sealing facility, should this be required.
- 4.4.3.2. Adjustments are to be made simultaneously on all poles, with a common adjustment facility.
- 4.4.3.3. MCCB's of 250amps up to 1600amps with thermal/magnetic trip units shall have fully interchangeable trip units.
- 4.4.3.4. MCCB's above 400 amps, the trip unit may be of a solid-state type, energised by internally mounted current transformers. It shall not require an external power supply to operate the tripping mechanism.
- 4.4.3.5. The current limiting MCCB's with very high breaking capacities must be capable of offering cascading and discrimination simultaneously.
- 4.4.3.6. The manufacturer shall provide a full set of current discrimination tables showing overload and short circuit discrimination, together with a full transparency set of characteristic curves, to enable discrimination systems to be checked.

4.5. Miniature Circuit Breakers

- 4.5.1. All miniature circuit breakers shall be rated to withstand the fault currents of the circuits they protect without causing any interference in any other protective device associated with the distribution system. At the same time, the design of the circuit breaker shall be such that it will protect the circuit for which it is intended and not cause or allow other protective devices to operate when fault conditions apply.
- 4.5.2. Miniature circuit breakers shall be in accordance with BS EN 60898-1: 2019 (IEC 898) and generally as detailed below:
- 4.5.3. General
 - 4.5.3.1. MCB's shall be fully tested to a minimum of 15KA as defined in BS EN 60898 and at 415V AC. All ratings of single, two, three, and four pole MCB devices shall meet this requirement.
 - 4.5.3.2. All MCB's shall directly indicate the true position of the contacts from the handle and shall comply with BS 7671 Latest Edition Wiring Regulations with regards to isolation and switching.
 - 4.5.3.3. MCB's shall be suitable for mounting in any DIN standard enclosure. Base mounting shall also be possible.
 - 4.5.3.4. MCB's shall be capable of accepting a full range of accessories.
- 4.5.4. Construction
 - 4.5.4.1. The operating mechanism shall be mechanically trip-free from the operating handle, to prevent the contacts from being held closed against short circuit or overload conditions. The mechanism shall automatically reset.
 - 4.5.4.2. The individual operating mechanism of each pole of a multi-pole MCB shall be directly linked within the MCB casing and not the operating handle.
 - 4.5.4.3. The operating handle shall be of the toggle type, with facility for mounting a padlocking device.
 - 4.5.4.4. Each pole shall be provided with a bi-metallic thermal element for overload protection and a magnetic element for short circuit protection.
 - 4.5.4.5. Terminals shall be of the cage or tunnel type, in order to minimise the risk of human contact, and shall be capable of being tightened with both conventional and cross point screwdrivers. All screws shall be of the captive type.
 - 4.5.4.6. MCBs shall be capable of accepting a full range of accessories, including earth leakage protection and remote tripping/indication modules. It shall be possible to fit these accessories either during initial installation of retrospectively and shall not require the use of any tools.
 - 4.5.4.7. MCBs shall be capable of accepting a full range of shrouding accessories, including terminal shields and inter-phase barriers.

4.6. Cartridges Fuses

- 4.6.1. All fuses shall comply with the requirements of BS88 and shall be supplied to suit the rating of the circuits protected or as specified.
- 4.6.2. All fuses in distribution switch, fuse gear and fused distribution boards shall be HRC Cartridge type and be ASTA certified at 80KA, 660V with fuse links having a class Q1 fusing factor (i.e. not exceeding 1.5) arranged

vertically and barriers shall be provided between phases. Unless protected by interlocked covers, all live parts shall be fully shrouded. Typed test certificates shall be provided if required by the Engineer.

- 4.6.3. All cartridge fuses shall be fitted with a device to indicate a blown element. Fuses shall be of the make and type specified in the particular specification.
- 4.6.4. Only one make and type of manufacturer shall be used throughout the installation to ensure proper discrimination between fuses is afforded.
- 4.6.5. For contactor control gear, the main circuit fuses shall be connected between the isolator and contactor.
- 4.6.6. Each fused switch and contactor unit shall be supplied with a spare set of fuses and the design of the equipment shall be such that means shall be provided for retaining the spare set of fuses within the fused switch or contactor cubicle compartment.
- 4.6.7. Unless otherwise stated within the particular specification, one half of each range of fuses shall be supplied for spares. The Contractor shall submit to the Engineer the curves and energy let through characteristics of the fuses intended to be used.

4.7. Residual Current Devices (RCBO's/RCD's)

- 4.7.1. Residual current devices shall be provided where shown on the distribution schedule within the particular specification. RCBO'S/RCDs shall be of the moulded case type, fault rated to suit the installation with an integral current operated earth leakage trip set for instantaneous operation on an earth fault level as the RCBO'S /RCD shall include a current selector to allow a selection of settings between 30 and 250 milliamps. A test switch shall be included, suitably labelled and easily accessible. RCBO'S /RCD's will comply as detailed below:
 - 4.7.2. General
 - 4.7.2.1. Earth leakage protection from 3 mA up to 3A and earth fault protection from 3A to 100A, shall be ensured by earth leakage/fault relays with separate sensors.
 - 4.7.2.2. The interrupting device shall be operated by either an under-voltage release or a shunt trip.
 - 4.7.2.3. The relay range shall include the following:
 - 4.7.2.4. Models with one or more fixed current threshold (up to six), with or without fixed time delays (up to four).
 - 4.7.2.5. Models with adjustable current thresholds and time delays by step-respecting discrimination rules.
 - 4.7.2.6. The relays shall comply with the following standards:
 - IEC 755
 - UTE 60 - 130
 - VDE 664
 - NFC 61 - 141 supp.1
 - 4.7.2.7. The auxiliary power supply shall be available in all standard voltage values (AC or DC).
 - 4.7.2.8. The relays shall be protected against nuisance tripping and have a surge current od at least 250A
 - 4.7.2.9. The relay range shall ensure up to four times discrimination levels.
 - 4.7.3. Construction
 - 4.7.3.1. Closed toroidal transformer mounting possibilities shall be as follows:
 - Directly on relay for 30mm and 50mm diameters
 - On symmetrical rail, in horizontal or vertical positions, up to 120mm diameter
 - Flat or perpendicular on plates for all models up to 200mm.
 - Directly on the cable for diameters from 80mm to 300mm.
 - 4.7.3.2. For installation purposes, depth shall not exceed 77mm. The relays shall be suitable for symmetrical rail, surface or flush mounting.
 - 4.7.3.3. The range of associated toroidal transformers shall include:
 - Closed type, with a maximum inside diameter of 300mm
 - Open type, with a maximum inside diameter of 110mm.
 - The different ratings within a given range shall be obtained without changing the type of toroidal transformer.

4.7.4. Safety Aspects

- 4.7.4.1. For models with adjustable current thresholds and the time delays, the relays shall be fitted with sealable transparent cover.
- 4.7.4.2. A break in the transformer-relay link shall be detectable with normal link. However, an integral test (current injection into the transformer) shall be used for relays with one or more threshold greater than 3 amps. Remote testing and/or reset shall be possible.
- 4.7.4.3. The basic construction material used for the cases of relays and toroidal transformers shall be polycarbonate, thereby ensuring a high dielectric strength and adequate insulation. The relays and toroidal transformers shall not require earthing.
- 4.7.4.4. The relay shall offer at least one output contact, but also the facility for two independent output contacts, one operating normally and the other providing positive safety. FAIL SAFE shall be available

4.7.5. Other RCD Applications.

- 4.7.5.1. Where portable residual current devices are required they shall comply with BS 7071:1992.
- 4.7.5.2. Where residual current devices are to be incorporated into socket outlets, they shall comply with BS 7288: 2019.

5. ACCESSORIES

5.1. General

- 5.1.1. The Contractor shall supply and install all accessories in the position indicated on the drawings and as defined within the particular specification.
- 5.1.2. All flush accessories shall have cover plates fitted flush to the wall, or ceiling, or adjacent surface.
- 5.1.3. All accessories shall be properly aligned with vertical edges plumb and horizontal edges level throughout.

5.2. Standards

- 5.2.1. As a minimum accessories will comply with the following standards:

- BS 1363 Socket Outlets (general)/Spur units
- BS EN 60309-1 Extra low voltage socket outlets
- BS EN 61558 Double wound transformers
- BS EN 60309-2 Industrial/weatherproof socket outlets
- BS 546 Plug Tops
- BS 5733 Shaver Sockets
- BS EN 60669-1 Light Switches

5.3. Socket Outlets

- 5.3.1. Socket outlets for general purpose shall be of the switched 13A rectangular pin type incorporating shuttered sockets in accordance with BS 1363. They shall be supplied as single or twin units as indicated on the drawings.
- 5.3.2. Unless otherwise stated all socket outlets will be installed flush.
- 5.3.3. Socket outlets for use in flush installations are to be fixed in zinc plated steel boxes complying with BS 4662 with 'Fly lead' earth connection between the back-box and the front plate.
- 5.3.4. Socket outlets for use with surface installations are to be the type specified and are to be galvanised where used in damp or potentially damp situations.
- 5.3.5. Extra low voltage socket outlets. Socket outlets for use on 110V and 25 V AC supplies shall be in accordance with BS EN 60309-1 and shall be either supplied from their own individual transformers or grouped on a common transformer as detailed within the particular specification. Where individual transformers are specified the transformer socket outlet and associated equipment shall be enclosed within a sheet metal enclosure arranged for wall mounting. In either case the transformers shall be double wound with a screen to conform to BS EN 61558.
- 5.3.6. Where 110V secondary windings are used they shall have an earthed centre tapping and fuses shall be provided in both output lines. The primary of all transformers shall be provided with a double pole isolating switch with a minimum rating of 20 amps.

5.4. Shaver Socket Outlets

- 5.4.1. Shaver socket outlets shall all be of the insulated type complying with BS 3535 having a double-wound transformer with earth screen between primary and secondary windings giving dual outlet supplies of 220 volts and 110 volts. The unit shall also be supplied complete with an on/off switch.
- 5.4.2. The unit shall be continuously rated at not less than 20 watts with self-resetting thermal overloads and with the output sockets arranged to receive the following plugs.
 - 240 volts
 - 5 amp 2 pin (BS 4573)
 - 10 amp 2 pin (Continental)
 - 110 volts
 - 10 amp 2 pin (Continental)
 - 10 amp flat pin (American)
- 5.4.3. Flush mounted units shall have over-lapping white moulded plates, or metal plates as specified. Units shall be mounted with zinc plated sheet steel boxes complying with BS 4662: 2006+A1:2009.
- 5.4.4. Surface mounted units shall be similar except that they shall be enclosed in surface mounting white moulded plastic boxes or sheet steel boxes to suit.

5.5. Fused Connection Units

- 5.5.1. Fused Connection Units shall be manufactured to BS 1363 and shall be of the flush or surface mounting type as defined within the particular specification and on the drawings. Mounting and installation arrangements in each case shall be as that required for socket outlets.
- 5.5.2. A withdrawal cartridge fuse of the size and ratings indicated within the particular specification shall be supplied and installed by the Contractor.
- 5.5.3. Fused Connection Units shall be supplied with a double pole switch and a neon indicating lamp.
- 5.5.4. Where no particular equipment is supplied or specified a 3amp cartridge fuse shall be supplied and installed.

5.6. Local Switches

- 5.6.1. Local switches for the control of lighting are to be 20amp rated type and comply with BS 3676 and are to be of the make, type, rating and finished specified.
- 5.6.2. Switches for AC use shall be of the slow break rocker type and for D.C use quick make and break shall be used.
- 5.6.3. The switch unit shall be fixed to a mounting grid or direct to the conduit box by means of two fixing screws. The cover plate shall be secured separately by means of additional screws to suit the switch plate.
- 5.6.4. Switches intended for lighting circuits shall generally have a single way, two way or intermediate configuration as defined within the particular specification.
- 5.6.5. Switches intended for use within automatic lighting controls shall be of the momentary contact type, of the types defined within the particular specification.
- 5.6.6. Switches for use with surface conduit installations in damp or potentially damp situations are to be metal clad types.
- 5.6.7. Switches for use in exterior locations are to be watertight and galvanised and are to be operated by a knurled rotary knob.
- 5.6.8. Where multiple switches are required they shall be mounted within a single enclosure.
- 5.6.9. Where the control of lighting circuits at one point involves the use of different phases, phase barriers shall be used and each phase or system identified at this point and labelled in accordance with the requirements of BS 7671: 2018.
- 5.6.10. All wall mounted switches shall be mounted square at heights as detailed elsewhere within this section of the specification. Precise details of mounting heights within tiled areas shall be in accordance with the Architects drawings and shall be subject to final positioning on site.

5.7. Ceiling Roses

- 5.7.1. Ceiling roses shall be of the surface mounting type and manufactured to BS 67 : 1987.
- 5.7.2. Luminaires not exceeding 0.5kg in weight may be connected direct to the ceiling roses fitted with strain wire facility. All other lighting fittings to be independently suspended and the final connection from the ceiling

rose to the luminaire to be carried out in a 3 core white circular heat resistant flexible card, as defined elsewhere within this specification.

- 5.7.3. Ceiling roses shall only be used for interior installations only.
- 5.7.4. Plug-in type ceiling roses shall be of the type and manufacture as defined within the particular specification. The pins shall be a minimum of 6A rated, 3 pin (4 pin for emergency lighting connections) with flex strain shoulders and the rose complete with screw on covers which lock in to the plug in position, plug-in type ceiling roses shall be securely fixed, independent of the luminaire or suspended ceiling to which they form part thereof.

5.8. Clock Outlets

- 5.8.1. Clock outlets shall be manufactured to BS EN 60335 and be of the type defined within the particular specification and shall be supplied complete with a 2 amp plug.
- 5.8.2. The clock outlet shall be installed so that it is concealed by the clock to which it is serving and be fused to BS 1362.
- 5.8.3. The clock outlet shall be, unless otherwise stated within the particular specification, be of the non-interchangeable type for different systems, i.e.; main synchronous, impulse and wired synchronous etc.

5.9. Small Power Isolators

- 5.9.1. Small power isolators shall consist of switches housed in sheet steel enclosures suitable for flush and or surface mounting as defined within the particular specification. The switches shall be suitable for the voltage and current ratings shown on the drawings. Unless otherwise stated switches shall be of the double-pole type for single phase circuits with solid neutral links and shall have a minimum current rating of not less than 20A.

5.10. Cooker Control Units

- 5.10.1. Cooker control units shall be manufactured to BS 4177. Unless otherwise stated cooker control units shall have a double pole switch connection, shall be installed flush and shall be labelled "cooker". They shall be supplied and installed without an auxiliary socket outlet unless otherwise defined with the particular specification.
- 5.10.2. The cooker control unit shall be connected to the apparatus to which it serves by means of single core interconnecting cables installed within a short run of conduit (25mm minimum diameter). The other end of the cables shall terminate into a purpose-made connection box.
- 5.10.3. Where the apparatus being served by the cooker connection unit is intended to be mobile to ease cleaning, final connection shall be afforded by means of flexible 25mm diameter conduit.

5.11. Flex Outlets

- 5.11.1. Flex outlets shall be installed flush unless otherwise stated within the particular specification. The flex outlet shall be supplied complete with a cord grip to securely anchor the outgoing flexible cables.
- 5.11.2. The cover plate shall be securely held to the flush mounted conduit box or otherwise, by fixing screws.

5.12. Plug Tops

- 5.12.1. The Contractor shall install the safety plug top complete with an appropriately sized cartridge fuse to any items of equipment provided by the client and or his representatives, for permanent installation.

5.13. Mounting Heights

- 5.13.1. Mounting heights for accessories shall be in compliance with the current Building Regulations at the time of installation. Particular attention shall be given to the section (Part M) dealing with 'Access and Facilities for Disabled People'.
- 5.13.2. Where particular items of equipment are not detailed the Contractor shall seek written confirmation from the engineer prior to mounting the item to any surface.
- 5.13.3. All dimensions stated within the Building Regulations are in millimetres and are taken from above finish floor level to the bottom, centre or top of that particular item of equipment depending on its' application.

6. LOW VOLTAGE CABLES

6.1. General

- 6.1.1. Unless otherwise defined within the particular specification cables shall be provided with any required terminations by the Contractor.

6.2. Standards

- 6.2.1. Cables and associated materials shall be supplied in accordance with all British and International Standards including, but not limited to the following:
- BS 6004 - PVC Insulated Cables. (non-armoured)
 - BS 7211:1989 - LSF Thermosetting Insulated Cables. (non-armoured)
 - BS 6724 - LSF Thermosetting Insulated Cables. (armoured)
 - BS 5467:1997 - XLPE Insulated Cables. (armoured)
 - BS 6480:1988 - Paper Insulated Cables.
 - BS 6622:2007 - Medium Voltage XLPE Insulated Cables.
 - BS 6207:2001 - MICS Cables.
 - BS 6346:1989 - Specification for PVC insulated cables for electrical supply.
 - BS 6360:1991 - Specification for conductors in insulated cables and cords.
 - BS 6746:1990 - Specification for PVC insulation and sheath of electric cables.
 - BS 6746C:1993 - Colour chart for insulation and sheath of electric cables.
 - BS EN 61238 - Specification for performance of mechanical and compression points in electric cable and wire connectors.
 - BS 6121-5:2005 - Mechanical Cable Glands.
 - BS 7846:2015 - Thermosetting insulated, armoured, fire-resistant cables.

6.3. Single Core PVC Insulated Cables

6.3.1. Materials:-

- 6.3.1.1. Single core PVC insulated cables up to 35sqmm (stranded 19/1.53) shall be 400/750 volt grade manufactured in accordance with BS 6004:2012 and by an approved Manufacturer. Conductors shall be stranded and of high conductivity annealed copper. No cable smaller than 1.5 sq. mm (stranded 7/0.53) shall be used.
- 6.3.1.2. Single core PVC insulated cables greater than 35 sq. mm shall be 600/1000 volt grade manufactured in accordance with BS 6346:1997 and by an approved manufacturer. Conductors shall be stranded and of high conductivity annealed copper.
- 6.3.1.3. The insulation shall be self-coloured to indicate the phase of the circuit, the polarity of d.c. circuits and to differentiate between separate electrical services. Unless otherwise stated the colour coding shall comply with the requirements of Table 51 of BS 7671. Cables shall be sized taking account of the applicable ambient temperature and grouping de-rating factors.

6.3.2. Installation:-

- 6.3.2.1. Cables for any circuit shall not be installed into conduit or trunking systems until:
- 6.3.2.2. The erection of the conduit and/or trunking system for that circuit is complete in every respect.
- 6.3.2.3. Earth continuity tests have been satisfactorily carried out.
- 6.3.2.4. All finishes except painting have been applied to the structure relevant to the particular run.
- 6.3.2.5. Any surplus finishes have been trimmed to the internal size of the boxes.
- 6.3.2.6. Any extension rings necessary to bring the rim of the box level with the finish have been installed.
- 6.3.2.7. Trunking and conduit systems are clean and dry. A swab shall be drawn through all conduit runs and trunking with fixed lid. Trunking shall be swept and wiped clean.
- 6.3.2.8. Cables shall be drawn from cable drums mounted on spindles to ensure they are installed without axial twisting. All the cables to be installed in one conduit run shall be installed at the same time. During installation the cables shall be combined to facilitate installation and withdrawal.
- 6.3.2.9. A suitable length of cable shall be left at all connection points and be coiled up and "put away" in their enclosure or box awaiting connection. Boxes which are not to be equipped with an accessory prior to painting, shall be fitted with their covers. No joints shall be allowed in cables except in boxes for accessories.

6.4. Single Core LSF Insulated Cables

6.4.1. Materials:

- 6.4.1.1. Single core LSF insulated cables shall be 450/750 volt grade manufactured in accordance with BS 7211:2012 and by an approved Manufacturer. Conductors shall be stranded and of high conductivity annealed copper. No cable smaller than 1.5 sq. mm (stranded 7/0.53) shall be used.
- 6.4.1.2. The insulation shall be self-coloured to indicate the phase of the circuit, the polarity of d.c. circuits and to differentiate between separate electrical services. Unless otherwise stated the colour coding shall comply with the requirements of Table 51 of BS 7671. Cables shall be sized taking account of the applicable ambient temperature and grouping de-rating factors.

6.4.2. Installation:

- 6.4.2.1. Cables for any circuit shall not be installed into conduit or trunking systems until:
 - The erection of the conduit and/or trunking system for that circuit is complete in every respect.
 - Earth continuity tests have been satisfactorily carried out.
 - All finishes except painting have been applied to the structure relevant to the particular run.
 - Any surplus finishes have been trimmed to the internal size of the boxes.
 - Any extension rings necessary to bring the rim of the box level with the finish have been installed.
 - Trunking and conduit systems are clean and dry. A swab shall be drawn through all conduit runs and trunking with fixed lid. Trunking shall be swept and wiped clean.
- 6.4.2.2. Cables shall be drawn from cable drums mounted on spindles to ensure they are installed without axial twisting. All the cables to be installed in one conduit run shall be installed at the same time. During installation the cables shall be combined to facilitate installation and withdrawal.
- 6.4.2.3. A suitable length of cable shall be left at all connection points and be coiled up and "put away" in their enclosure or box awaiting connection. Boxes which are not to be equipped with an accessory prior to painting, shall be fitted with their covers. No joints shall be allowed in cables except in boxes for accessories.

6.5. PVC Insulated, PVC Sheathed, Armoured Power Cables.

6.5.1. Materials :

- 6.5.1.1. PVC insulated, PVC sheathed, armoured multicore and single core power cables shall be 600/1000 volt grade manufactured in accordance with BS 6346:1997 and by an approved manufacturer. It shall consist of high conductivity annealed copper stranded conductors, and single layer of galvanised steel wire armour. The cables shall incorporate a PVC oversheath coloured Black.
- 6.5.1.2. No cable smaller than 1.5 sq. mm (stranded 7/0.53) shall be used.

6.5.2. Core Identification :

6.5.2.1. Number of Cores & Core Colours

- Single as appropriate
- Two brown, blue
- Three brown, grey, black
- Four brown, grey, black, blue

6.5.2.2. Blue denotes the neutral and other colours the phase.

6.5.3. Cable Identification:

- 6.5.3.1. Each end of a cable shall be provided with an identification label. Labels shall be permanently attached to the cables in an approved manner, loose tags will not be accepted. The materials of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials and to ensure permanent legibility. All identification shall be in accordance with BS 3858:1992 and BS 5559:1991.

6.5.4. Installation:

- 6.5.4.1. Cables shall be installed in accordance with the requirements of BS 7671 & BS 6346:1997, and the manufacturer.
- 6.5.4.2. Cables shall be delivered to site, and stored, on a cable drum with the manufacturers label attached.

- 6.5.4.3. Cables shall be fixed to cable trays, the building fabric/structure, laid in trenches and installed in ducts as detailed on the drawings.
- 6.5.4.4. A clearance of 300mm is to be maintained between cables and other equipment or pipework, including lagging etc. Where this condition is difficult to comply with, a ruling is to be obtained from the engineer prior to the installation being commenced. If this is not done the engineer may require the cable to be diverted or fixings adjusted at no additional cost.
- 6.5.4.5. Cables shall be supported using claw cleats at centres not exceeding the manufacturers' recommendations, and that defined within BS 7671 IEE Wiring Regulations latest Edition, whichever is the more onerous.
- 6.5.4.6. Additional cable cleats are to be provided on cable routes which are subject to numerous changes in level and direction or where structural beams or other building features or pipework ducts etc. exist so that cables clearly and neatly negotiate all such obstacles.
- 6.5.4.7. Fixings used in damp, potentially damp or exterior locations are to be hot dipped galvanised after manufacture.
- 6.5.4.8. The minimum internal bending radius of the cables shall not be less than those detailed by the manufacturer, and that defined within BS 7671 IEE Wiring Regulations Latest Edition, whichever is the more onerous.
- 6.5.4.9. Care is to be taken to ensure that the cables are not twisted or kinked.
- 6.5.4.10. The current ratings of cables have been based upon:-
 - Single layer of cables on perforated trays touching.
 - Buried at 450mm below ground level not bunched.
- 6.5.4.11. Cables shall be installed only using these methods, i.e.: stacking of cables will not be permitted.
- 6.5.4.12. Care is to be exercised in the handling of cables.
- 6.5.4.13. To facilitate the installation of cables the drums shall be supported by either Jack stands or a drum cradle to allow the cable to rotate freely, and they are to be rolled smoothly in the direction of the arrow painted on the side of the drum, whilst the cable is drawn through ducts laid in trenches or on cable trays. Cable rollers are to be used as necessary.
- 6.5.4.14. Wire cable stockings are to be used with pulling ropes when pulling cables through ducts.
- 6.5.4.15. The Contractors attention is drawn to the need to observe the warnings provided in BS 6346:1989 which relate to the cables being installed during periods of low temperature which states "to avoid damage during handling, the cable shall only be installed when both the cable and the ambient temperatures are above 0 deg C and have been so for the previous twenty four hours, or where special precautions have been taken to maintain the cable temperature".
- 6.5.4.16. Once all cables have been drawn into ducts, all holes shall be sealed by a waterproof sealing compound to prevent the ingress of water, vermin etc.
- 6.5.4.17. Where cables are run in trenches they shall be installed at a constant minimum depth of 450mm. below finished ground level. The Contractor shall be responsible for ensuring their cables are back-filled with 100mm cover of stone free graded earth or sand.
- 6.5.4.18. The Contractor shall install a continuous warning marker tape 250mm. below finished ground level along the full length of the cable route.
- 6.5.4.19. No joints will be permitted along the cable run.
- 6.5.4.20. Where cables pass through walls, floor, ceiling etc. the holes shall be made good with incombustible material to prevent the spread of fire. Where the walls, floor etc. form a fire barrier the cables shall be enclosed in a steel sleeve and space around the cable in the sleeve shall be plugged with insulating material.
- 6.5.5. Termination:
 - 6.5.5.1. The method of stripping the sheath, filler and insulation shall be as recommended by the cable manufacturer and shall be such that no damage is caused to the insulation or conductor. Each cable gland shall be fitted in accordance with the manufactures recommendations and shall be of the correct type and size for the specific application and location. All joint faces shall have suitable gaskets. Glands for single core power cables, if metal sheathed, shall be fixed on non-ferrous metal plates, so arranged as to prevent the flow of eddy currents in the cable boxes.
 - 6.5.5.2. Cable glands for PVC insulated cables shall as a minimum be of the two stage compression type which grip both the cable sheath and the armouring independently and incorporate an external earthing lug. A black PVC shroud shall be installed.

- 6.5.5.3. Where a cable gland connection is made to a metal cable box or plate, a bolted earth connection shall be provided
- 6.5.5.4. Three stage weatherproof glands will be used for all external cable terminations.
- 6.5.5.5. Cable tails shall be terminated onto equipment by means of solderless compression type cable lugs applied to the conductor by means of a hydraulic crimping tool. Cables entering cable end boxes, switchboards and other electrical equipment shall be installed straight for a distance of not less than 300mm from the cable gland.

6.6. XLPE, Insulated, PVC Sheathed, Armoured and Un-armoured Power Cables and LSF Applications.

6.6.1. Materials:

- 6.6.1.1. XLPE, Insulated, PVC Sheathed Armoured multicore power cables shall be 600/1000 volt grade manufactured in accordance with BS 5467:1997 and by an approved manufacturer. It shall consist of high conductivity annealed copper stranded conductors,
- 6.6.1.2. XLPE insulated, extruded bedding, and a single layer of galvanised steel wire armour.
- 6.6.1.3. The cables shall incorporate a PVC oversheath coloured black.
- 6.6.1.4. In instances where low smoke zero Halogen armoured cables are detailed, the following shall apply:
 - XLPE Insulated, LSF Sheathed Armoured multicore power cables shall be 600/1000 volt grade manufactured in accordance with BS 6724 and by an approved manufacturer. It shall consist of high conductivity annealed copper stranded conductors, XLPE insulated, LSF fillers and binders, LSF extruded bedding, and single layer of galvanised steel wire armour. The cables shall incorporate an LSF oversheath coloured black. Reference should also be made to section 10.10 of this specification.
 - Core Identification
- 6.6.1.5. Number of Cores & Core Colours
 - Single as appropriate
 - Two brown, blue
 - Three brown, grey, black
 - Four brown, grey, black, blue
 - Five brown, grey, black, blue, green/yellow
- 6.6.1.6. Black denotes the neutral and other colours the phase.
- 6.6.1.7. Integral earth conductor sheath always to be green/yellow

6.6.2. Cable Identification:-

- 6.6.2.1. Each end of cable shall be provided with an identification label. Labels shall be permanently attached to the cables in an approved manner, loose tags will not be accepted. The materials of the labels and fastenings shall be such as to avoid corrosion due to incompatibility of materials and to ensure permanent legibility. All identification shall be in accordance with BS 3858:1992 and BS 5559:1991.

6.6.3. Installation

- 6.6.3.1. Cables shall be installed in accordance with the requirements of BS 7671 & BS 6346:1989, and the manufacturers recommended procedures and guidelines.
- 6.6.3.2. Cables shall be delivered to site, and stored, on a cable drum with the manufacturers label attached.
- 6.6.3.3. Cables shall be fixed to cable trays, the building fabric/structure, laid in trenches and installed in ducts as detailed on the drawings.
- 6.6.3.4. A clearance of 300mm is to be maintained between cables and other equipment or pipework, including lagging etc. Where this condition is difficult to comply with a ruling is to be obtained from the Engineer prior to the installation being commenced. If this is not done the Engineer may require the cable to be diverted or fixings adjusted at no additional cost.
- 6.6.3.5. Cables shall be supported using claw cleats with LSF properties where such cables are used, at centres not exceeding the manufacturers' recommendations.
- 6.6.3.6. Additional cable cleats are to be provided on cable routes which are subject to numerous changes in level and direction or where structural beams or other building features or pipework, ducts etc., exist, so that cables clearly and neatly negotiate all such obstacles.

- 6.6.3.7. Fixings used in damp, potentially damp or exterior locations are to be hot dipped galvanised after manufacture.
- 6.6.3.8. The minimum internal bending radius of the cables shall not be less than those detailed by the manufacturer.
- 6.6.3.9. Care is to be taken to ensure that the cables are not twisted or kinked.
- 6.6.3.10. The current ratings of cables have been based upon:-
 - Single layer of cables on perforated trays touching.
 - Buried at 450mm below ground level not bunched.
- 6.6.3.11. Cables shall be installed only using these methods, i.e.: stacking of cables will not be permitted.
- 6.6.3.12. To facilitate the installation of cables the drums shall be supported by either Jack stands or a drum cradle to allow the cable to rotate freely whilst the cable is drawn through ducts laid in trenches or on cable trays.
- 6.6.3.13. Wire cable stockings are to be used with pulling ropes when pulling cables through ducts.
- 6.6.3.14. The Contractors attention is drawn to the need to observe the warnings provided in BS 6346:1989 which relate to the cables being installed during periods of low temperature which states "to avoid damage during handling, the cable shall only be installed when both the cable and the ambient temperatures are above 0 deg C. and have been so for the previous twenty four hours, or where special precautions have been taken to maintain the cable for the temperature".
- 6.6.3.15. Once all cables have been drawn into ducts, all holes shall be sealed by a waterproof sealing compound to prevent the ingress of water, vermin etc.
- 6.6.3.16. Where cables are run in trenches they shall be installed at a minimum constant depth of 450mm. below finished ground level. The Contractor shall be responsible for ensuring their cables are back-filled with 100mm cover of stone free graded earth or sand.
- 6.6.3.17. The Contractor shall install a continuous warning marker tape 250mm. below finished ground level along the full length of the cable route.
- 6.6.3.18. No joints will be permitted along the cable run.
- 6.6.3.19. Where cables pass through walls, floor, ceiling etc. the holes shall be made good with incombustible material to prevent the spread of fire. Where the walls, floor etc. form a fire barrier the cables shall be enclosed in a steel sleeve and space around the cable in the sleeve shall be plugged with insulating material.
- 6.6.4. Termination:
 - 6.6.4.1. The method of stripping the sheath, filler and insulation shall be as recommended by the cable manufacturer and shall be such that no damage is caused to the insulation or conductor. Each cable gland shall be fitted in accordance with the manufactures recommendations and shall be of the correct type and size for the specific application and location. All joint faces shall have suitable gaskets. Glands for single core power cables, if metal sheathed, shall be fixed on non-ferrous metal plates, so arranged as to prevent the flow of eddy currents in the cable boxes.
 - 6.6.4.2. Where a cable gland connection is made to a metal cable box or plate, a bolted earth connection shall be provided
 - 6.6.4.3. Cable glands for PVC insulated cables shall as a minimum be of the two stage compression type which grip both the cable sheath and the armouring independently and incorporate an external earthing lug. A black PVC (or LSF where such cables are used) shroud shall be installed. Three stage weatherproof glands will be used on all external terminations.
 - 6.6.4.4. Cable tails shall be terminated onto equipment by means of solderless compression type cable lugs applied to the conductor by means of a hydraulic crimping tool. Cables entering cable end boxes, switchboards and other electrical equipment shall be installed straight for a distance of not less than 300mm from the cable gland.

6.7. Paper Insulated Lead Armoured PVC Sheathed Cables.

6.7.1. Materials:

6.7.1.1. The construction of the cable shall comply with BS 6480:1988, and shall:

- be 600/1000 volt Grade, be of mass impregnated, non-draining type.
- have conductors of stranded copper, stranded aluminium or solid aluminium as called for in subsequent sections, schedule of works or the (sub) contract drawings.
- have lead or lead alloy sheath.
- be installed in one continuous length, joints will not be permitted without the written permission of the supervising officer.
- be kept sealed by means of wiped joint and caps until termination work commences.
- not be installed in contact with polystyrene.

6.7.2. Multicore cables shall be PVC sheathed overall.

6.7.3. Termination:

6.7.3.1. Cable shall be terminated in accordance with the following methods:-

- Multicore cables shall be terminated at brass or cast-iron sealing boxes. The sheath shall be plumbed to a brass gland and the armouring clamped by means of a purpose-made clamp. The sealing boxes shall be filled with a hot-pouring compound complying with BS 1858. The sealing boxes shall be flanged for direct connection to the equipment served.
- Each single core cable shall be terminated at a brass sealing box. The sheath shall be plumbed to a brass gland and the sealing box filled with a hot-pouring compound complying with BS 1858. The sealing boxes shall be fixed to a non-metallic or brass plate or a steel plate with slots cut between the cable entry holes. Steel plates shall also have a plate of insulating material to seal the slots.
- As an alternative to plumbed terminations, a purpose-made heat-shrinkable termination may be used. The approval of the Engineer to the system proposed shall be obtained before that section of work is put to hand. The termination shall be carried out in strict accordance with the manufacturers' recommendations.
- Where the cable cores are connected directly to the equipment served then the paper insulation shall be removed to below compound level, or within the heat-shrinkable cap or sleeve, and replace by 2 half-lap layers of varnished cambric tape complying with BS 419 and 1 half-lap layer of PVC tape. Stranded cable core shall be sweated solid below compound level or within the heat-shrinkable cap or sleeve.
- Where insulated tails are used, these shall be connected to the cores by means of a split soldering ferrule or a compression sleeve below compound level or within the heat-shrinkable cap or sleeve.
- The armour and/or sheath shall be bonded at both ends by means of a copper tape or single core, green PVC, cable sized in accordance with the requirements of BS 7671.

6.7.3.2. Where joints are proposed the Contractor shall obtain the approval of the Engineer to the methods proposed.

6.8. Mineral Insulated Cables

6.8.1. Materials:

6.8.1.1. Cables shall comply with BS:6207. Cables shall be 600 volt class (light-duty) except that where the nominal cross-sectional area of conductor or the number of cores required is outside the range of 600 volt class (light duty) then 1000 volt class (heavy duty) cables shall be used.

6.8.1.2. Cables shall have an LSF outer covering when:

- They are laid upon or fixed direct to a concrete or stone surface subject to dampness.
- They are laid upon or fixed direct to a zinc coated surface, e.g. a galvanised cable tray or corrugated sheeting, subject to dampness.
- They are buried direct in the ground.
- Installed on combustible surfaces.
- Required by BS 7671.
- So indicated or when directed by the Engineer.

- So indicated or when directed by the particular specification.

6.8.1.3. The LSF outer covering shall be coloured orange for category 1 circuits, red for category 2 fire alarm circuits and white for emergency lighting circuits.

6.8.2. Terminations:

6.8.2.1. Terminations shall comply with BS 6081:1989 as applicable. Sealing pots shall be marked with the appropriate cable reference. Insulating sleeves shall be marked with the normal cross-sectional area of the conductor. The temperature classification of the seal shall be class 105°C unless otherwise indicated or directed by the Engineer. Glands shall be type A and PVC or LSF shrouds over glands shall be provided when PVC or LSF covered cables are used. Before applying a shroud, all bare metal shall be wrapped with pressure sensitive adhesive PVC tape. Where sealing pots are formed from aluminium alloy, they shall not be placed in direct contact with dissimilar metals or be allowed to come into contact with plaster or concrete; insulating tape may be used to prevent such contact.

6.8.2.2. Where cables are terminated in standard or dust proof enclosures, a gland is not required and a sealing pot only need be employed provided other mechanical means are adopted to maintain electrical continuity of the metallic sheath.

6.8.2.3. The mechanical means of providing electrical continuity may be an integral part of the enclosure. Where cables are terminated in enclosures buried in lightweight screeds, a gland shall be employed.

6.8.2.4. If sealing pots incorporate an earthing tail, the efficiency of the mechanical and electrical bond of the earthing conductor to the pot shall not depend entirely on a soldered joint.

6.8.3. Saddles and Clips:

6.8.3.1. Saddles and clips may be of metal may be single hole fixing. Where cables have an LSF outer covering, metal saddles with a LSF covering shall be used.

6.8.3.2. Where cables are to be supported on a perforated cable tray, fixing screws shall be round head brass complying with BS 450. Nuts shall be of brass square pressed type complying with BS 2827. Screws for surface internal or external runs shall be round head brass. Screws for concealed internal fixings shall be steel.

6.8.4. Jointing Sleeves:

6.8.4.1. Jointing Sleeves shall be of brass with standard terminations. Solder ferrules shall be used to join the conductors; the solder used shall comply with BS 219, type M. Non-corrosive flux only shall be used. Resin or flux, complying with the Department of Trade and Industry specification DTD 599A, will be accepted.

6.8.5. Installations:

6.8.5.1. As indicated or as directed by the Engineer, cables shall be:

- Run neatly on the surface of the building or in roof, ceiling or floor voids.
- Buried in the carcase of the building within suitably sized conduits.
- Fixed neatly in trenches, drawn into ducts or secured to cable tray.

6.8.5.2. All cable routes shall be determined by the Contractor and agreed by the Engineer before work is started. Cables shall be run at least 150mm clear of all plumbing and mechanical services. The use of conduit and/or cable trunking to enclose conductors shall be kept to the minimum.

6.8.5.3. Cables shall be terminated at apparatus or joining boxes. Conductors shall be directly connected to terminals on or within the apparatus or to each other. A loop shall be introduced in a cable immediately before its entry into equipment subject to vibration or occasional movement.

6.8.5.4. Tools required for the manipulation and termination of cables shall be of a design approved by the cable manufacturers. Corrugation of the copper sheath at bends will not be accepted. A wood block or a wooden faced tool shall be used to finally dress the cables into position.

6.8.5.5. Care shall be exercised during stripping of the sheath and fitting of the sealing pot to ensure that:

- The sheath is not bellied inwards and burrs are not left which could reduce the design clearance between sheath and conductor(s).
- The sealing pot is correctly positioned relative to the cut end of the sheath.
- All loose powder is removed.
- The interior of the sealing pot is free of any metal particles formed during the process of attaching the pot to the cable.
- The insulating sleeving is correctly placed relative to the closure of the mouth of the pot.
- Phase conductors shall be indicated by means of appropriately coloured PVC insulating tape adhered to the insulating sleeve.
- All air is excluded from the sealing pot by the correct introduction of the plastic filling.

6.8.5.6. Plastic filling compound shall be stored in dust-tight containers when not actually in use. It shall not be used if it is, or is suspected to be, contaminated by dirt or moisture. A 500 volt instrument shall be used to check the insulation resistance of completed seals. The reading shall be infinity in all instances. Where a cable crosses an expansion joint in a building, it shall be wrapped with waterproof building paper for a distance of 300mm on each side of the joint.

6.8.6. Single Core Cables:

6.8.6.1. Large single core cables run together shall be laid up in twisted formation at Works or laid with the cable sheaths in contact. Cables for 3-phase circuits shall be laid in trefoil formation. Gland plates of apparatus shall be of non-ferrous metal.

6.9. Low Smoke and Fume Emission Power Cable (LSF).

6.9.1. Materials:

6.9.1.1. Cables supplied to this specification shall be rated at 600/1000 volts or 1900/3300 volts. They shall be manufactured with materials which are nominally free from halogens and which have the following characteristics in a fire situation.

- Low smoke generation
- Minimal noxious fume emission
- No evolution of hydrochloric acid gas

6.9.1.2. Cables shall be generally to BS 5467:1990 and BS 6724:1990 and shall be suitable for operating at a continuous conductor temperature of 90 degrees C.

6.9.2. Construction:

6.9.2.1. Conductors shall be stranded copper, circular for single core and circular or shaped for multi-core cables. They shall comply fully with the requirements of BS 6360:1991. The insulation shall be XLPE complying with the requirements of Compound GP8 of BS 6899:1991. The minimum thickness and tolerances shall be in accordance with BS 5467:1990. Core identification shall be by pigmentation of the insulation.

6.9.2.2. Fillers and binders used at laying-up shall be of low smoke, zero halogen material. The bedding shall be an extruded layer of low smoke, zero halogen material easily removable from the core insulation. The armour shall be a single layer of galvanised steel wires on multicore cable or of aluminium wires on single core cable. The armour shall comply with the requirements of BS 5467:1990.

6.9.2.3. The oversheath shall be an extruded layer of low smoke, zero halogen material. In addition to the embossing specified in BS 5467:1990, the cables shall also be embossed with the letters "LSF".

6.9.2.4. Care must be taken to avoid maltreatment during installation, because LSF insulations are less robust than PVC and are more prone to scuffing and abrasion damage. Bending radius: not less than eight times the cable diameter.

6.10. Fire Rated Cable

- 6.10.1. All fire rated cables shall be design and approved to BS 7846 and BS 8491 respectively.
- 6.10.2. All life safety services and fire-fighting systems shall be wiring using fire rated cable with a fire survival duration of at least 60 minutes unless a risk assessment specifies otherwise.
- 6.10.3. Material:
 - Plan annealed copper stranded circular to comply with BS EN 60228.
 - Primarily insulated with Mineral ceramic (mica/glass) fire resistance tape
 - Secondary insulation 90 degrees cross link insulation
 - Two core – Black and Blue
 - Three core – Brown, Black and Grey
 - Four core Blue, Brown, Black and Grey
 - LSOH sheath and bedding compound

6.11. Low Smoke Zero Halogen Screened Cables.

- 6.11.1. Materials:
 - 6.11.1.1. Fire resistant cables shall have silicone rubber insulated copper conductors with an aluminium foil screen sheathed overall with hard grade PVC compound. Non insulated copper conductors laid up with the insulated conductors and in contact with the aluminium screen shall form the earth continuity conductor. Cables shall have a voltage rating of 300/500 volts.
 - 6.11.1.2. Materials required for the termination of the cables which include plastic ferrules, cable glands, support clips etc., shall be in accordance with the cable maker's recommendations.
- 6.11.2. Installation:
 - 6.11.2.1. Cable shall be run on the surface, buried direct in to building finishes, laid into cable trunking or drawn into runs of conduits which shall have no more than two 45 degree bends of a radius at least equal to the minimum bending radius of the cable.
 - 6.11.2.2. No more than one cable shall be drawn into any conduit.
 - 6.11.2.3. The Manufacturer's installation instructions shall be deemed to be part of this Specification and the recommendations with respect to fixing, bending, terminating etc., shall be strictly adhered to. A copy of the installation instructions shall be in possession of all operatives concerned with the installations.

6.12. Control Cables

- 6.12.1.1. The type of cable to be used shall be in accordance with the particular specification and shall be one of those mentioned previously. The construction of the conductors, insulation and armouring is consequently defined. The coding of the cables shall be as follows:
- 6.12.1.2. Number of Cores & Core Colours

• Single	black
• Two	red, black
• Three	red, yellow, blue
• Four	black with white numeral
• Five and above	black with white numeral
- 6.12.1.3. Minimum size shall be 1.5 sq. mm.

6.13. Instrumentation Cables

6.13.1. Construction:

Pair	Pair	Pair	Pair	Pair	Pair	Last
Number	1	2	3	4	5	Pair
Wire	A B	A B	A B	A B	A B	A B
1 Pair Centre	O W					
2 Pair Centre	O W	G B				
3 Pair Centre	O W	R Gr	G B			
4 Pair Centre	O W	R Gr	Bl Br	G B		
5 Pair Centre	O W	R Gr	Bl Br	R Gr	G B	
Layers	O W	R Gr	Bl Br	R Gr	Bl Br	G B
and so on with even and odd pairs to: Green Black						
O =	Orange					
W =	White					
R =	Red					
G =	Green					
B =	Black					
Gr =	Grey					
Bl =	Blue					
Br =	Brown					

- 6.13.1.1. Instrumentation cables are rated at 60 volts core to earth and 120 volts core to core and are used to connect electronic instrument circuits and provide communication services.
- 6.13.1.2. The conductors are 1/0.80, 1/1.13 or 16/0.20mm plain copper. The insulation shall be polyethylene. Individual pair screens shall be 0.024mm thick, laminated, bonded aluminium/PETP tape overlapped. Screen isolation tape shall be PETP (transparent) overlapped and numbered for pair identification. Bender tapes shall be PETP (transparent) overlapped. Filler shall be polythene treads as required.
- 6.13.1.3. Collective screen and heat barriers shall be 0.024mm thick laminated, bonded aluminium/PETP tape overlapped. The drain wire shall be 1/0.80mm tinned copper drain wire in contact either with pair screen, or collective screen. Bedding shall be PVC. Armouring shall be single layer of galvanised steel wire. Sheath shall be PVC black.

6.13.2. Identification:

- 6.13.2.1. Cables not having individual screened cores are identified as follows:
- 6.13.2.2. Two pair cables are laid up as a quad and are colour coded in clockwise order of rotation as follows: - orange, green, white, black. For cables having individually screened pairs, all pairs are coloured orange and white with pair identification by numbered tapes.

7. EXTRA LOW VOLTAGE DATA CABLES

- 7.1.1. For further details of extra low voltage cables, please refer to particular specification.

8. BUSBAR TRUNKING SYSTEMS

8.1. General

- 8.1.1. Where detailed within the particular specification all busbar trunking shall be supplied by the Electrical Contractor, complete with straight lengths (3 & 5 meters), elbows, tees, feed units, end covers, plug-in, tap-off units, fixing brackets etc. All busbar trunking and tap-off units will be of the size and ratings indicated within the particular specification.
- 8.1.2. A white on red "Traffolyte" type, **DANGER 415 VOLTS A.C** label shall be supplied and fixed by the Electrical Contractor at 3m. intervals along the side of each busbar trunking length and at elbows and tee connections.
- 8.1.3. The busbars shall be used for single/three phase and neutral supplies complete with protective conductors. Neutral connections to all tap-off units shall utilise solid links.
- 8.1.4. The busbar tap-off units shall be suitably labelled for identity, phase, voltage and the equipment it is solely supplying.
- 8.1.5. The busbars shall be adequately supported from either the roof steelwork/purlins system with M10 steel thread rods, suitably clamped using type Z clamps and securely fixed to the manufacturers support clamps at centres not exceeding the manufacturer's recommendations.
- 8.1.6. The tap-off units shall be of the same manufacture and where pre-wired single phase tap-off units are specified within the particular specification. It shall be the Contractors responsibility to advise the manufacturer of the quantity and phases required.
- 8.1.7. Special care shall be taken when fitting the centre feed units to each run of the busbar trunking to ensure that the correct phasing sequence is maintained throughout its run.
- 8.1.8. Tinned copper earthing lugs complete with suitably sized copper conductors shall be terminated into each centre feed unit from its original supply to maintain earth continuity throughout.
- 8.1.9. The Electrical Contractor shall be responsible for the storing of the above equipment prior to installation ensuring that the equipment is not subject to ingress of damp or dust.
- 8.1.10. The Electrical Contractor shall ensure that the busbar systems are complete and properly fixed/fitted in accordance with the manufacturer's instructions before any connection is made to the supply.
- 8.1.11. Where a larger busbar system (main feeder) supplies another busbar system (primary), the interconnections shall be carried out using suitably sized single core cables enclosed within flexible conduit; the connection length shall be limited to 1 metre.

8.2. Standards

- 8.2.1. BS 5486 part 2 - Particular requirements for busbar trunking systems (busbars).
- 8.2.2. BS 5420 - Degree of Protection.

8.3. Trunking Rated up to 40 Amperes

- 8.3.1. Unless otherwise stated within the particular specification all busbar trunking shall be manufactured with 20/40 Ampere, copper conductors with internal insulation. The trunking body shall be finished in zinc coated sheet steel.
- 8.3.2. The trunking shall be fitted with internal tap-off outlets at 0.5 metre intervals. All tap-off points will be shrouded.
- 8.3.3. The end feed unit shall be capable of accepting 6 mm² single core cables internally supported by suitable cable clamps.
- 8.3.4. Each section of busbar trunking shall ensure earth continuity throughout.
- 8.3.5. Where the busbar trunking system is used to supply and support fluorescent luminaires, the Contractor shall ensure that the luminaire is fixed as per the manufacturer's recommendations.
- 8.3.6. The Contractor shall also ensure that the busbar trunking body deflection does not exceed the manufacturer's recommendations. The Contractor shall ensure that the complete trunking run does not deflect laterally by more than 10mm throughout its entire length.
- 8.3.7. Tap-off Units
 - 8.3.7.1. The Contractor shall supply, install and connect the required number of tap-off units which shall be of the type and ratings as defined within the particular specification.

- 8.3.7.2. Where multi-conductors are used within the same trunking body the contractor shall ensure that the trunking tap-off units are correctly installed to the appropriate tap-off conductors.
- 8.3.7.3. The tap-off units shall be adequately labelled as to its use when supplying emergency lighting circuits.
- 8.3.7.4. The Contractor shall be responsible for ensuring that the correct numbers of tap-off units are plugged into the correct busbar trunking circuits so as not to overload the busbar trunking system.

8.4. Busbar Trunking Systems Rated Between 63-800A

- 8.4.1. Unless otherwise stated within the particular specification all busbar trunking from 63A up to and including 800A, shall be manufactured with aluminium conductors, suitable for use with 415 volts, 50Hz and complete with an internal degree of protection of not less than IP40. The trunking body shall be finished in a galvanised sheet steel totally enclosing casing.
- 8.4.2. The trunking shall be supplied with internal tap-off outlets at not less than 500mm intervals on both sides, throughout its entire length. The trunking supports shall be installed so as not to cover or prevent use of the trunking tap off outlets.
- 8.4.3. The trunking system shall be provided with silver plated copper surfaces at all busbar points and plug in outlets to ensure that long lasting electrical contact is maintained through the life of the system.
- 8.4.4. The tap-off units shall be capable of being installed into position, with the busbar trunking system live, via mechanical interlocks which shall prevent the following:-
 - Plugging in of the tap-off unit with the door closed.
 - Closing of the door if the tap-off is not correctly plugged in.
 - Removal of the tap-off unit with the door closed.
- 8.4.5. The casing of each tap-off unit shall be constructed of galvanised sheet steel.
- 8.4.6. The Contractor shall ensure that where tap-off units are specified having internal outgoing circuit protection the correct tap-off unit is supplied with one of the following:
 - HRC fuses to BS 88
 - Miniature Circuit Breakers to BS 3871, or BS EN 60898
 - Moulded Case Circuit Breakers to BS 4752, or BS EN 60947-2
- 8.4.7. It shall be the Contractors responsibility to ensure that the correct device is used within each tap-off unit to ensure that the correct rating and fault withstand capabilities of the device at the point of installation is afforded at all times.
- 8.4.8. Plug in outlets shall be manufactured complete with automatic protective shutters which are activated by the tap-off units.
- 8.4.9. All jointing devices used between the trunking lengths shall be of the mechanical and electrical type, with a separate protective earth conductor to ensure earth continuity throughout the entire length.
- 8.4.10. The Contractor shall ensure that each section of the busbar trunking is locked into position and is adequately connected.
- 8.4.11. The trunking body shall be installed in the upright position with the tap off outlets accessible from each side.
- 8.4.12. The trunking will be supported using the manufacturers' proprietary brackets and suspension systems, at the manufacturers defined centres.

9. CABLE MANAGEMENT SYSTEMS

9.1. General

- 9.1.1. Cables shall be delivered on drums and properly protected against mechanical damage. Each drum when delivered, shall be accompanied by a certificate giving manufacturer's name, works order number and results of tests made at works. Where lengths are cut from cables, the open ends shall be sealed.
- 9.1.2. Where cables of differing voltages are installed in close proximity, cable identification shall be provided.
- 9.1.3. Cables will be installed on cable trays, cable ladders, in trunking, fixed to structures with "Unistrut" (or equal and approved similar system) and clamps/cleats direct buried or in ducts as shown on the drawings. Any other type of installation of fixing shall require authorization by the Engineer.

9.2. Cables on Trays and Ladders:

- 9.2.1. Cables shall be installed on trays or ladders such that each cable runs parallel to its neighbour and be neatly laid in rows such that as cables leave the tray or ladder they do not cross over other cables.

- 9.2.2. Cables leaving trays should either pass through the bottom of the tray through neatly cut holes with suitable grommets or over the return flange, the cable should be supported away from the flange. Depending on the size of the slot the tray should be either strengthened or have further support. Cables shall not leave the tray and trail over the return flange.
- 9.2.3. Cables leaving ladder shall pass through the rungs of the ladder. Only two layers of cables shall be allowed on trays unless approved by the Engineer. Cables on ladders may have more than two layers but the top of the uppermost cable must be below the edge of the ladder flange.
- 9.2.4. Cables where not specified to be cleated shall be tied to the tray or ladder by plastic cable ties minimum size of 5mm and at such intervals to prevent "bowing" of the cables. Power cables should be segregated as far as possible and tied down individually.
- 9.2.5. High Voltage Cables on Trays and Ladders:
 - 9.2.5.1. HV/MV cables shall be installed on separate trays or ladder in order to provide separation from low voltage and control cables. HV/MV cables shall be fixed, supported or restrained by means of proprietary cleats in accordance with manufacturer's guidance.
 - 9.2.5.2. Instrumentation cabling shall also be installed on separate trays or ladders where necessary to prevent induced signals.
- 9.2.6. Bending Radii of Cables:-
 - 9.2.6.1. Bends in cables shall be as large as possible and in accordance with the cable Manufacturer recommendations.
- 9.2.7. Cleats and Saddles :-
 - 9.2.7.1. Cable cleats shall be manufactured in pressure die cast silicon aluminium grade LM6-M to BS 1490: 1988. Cable cleats shall be manufactured in two identical halves and secured to the support system by two studs or bolts suitable for fixing to the support system. These shall be provided in all vertical and horizontal runs of cables.
 - 9.2.7.2. Cleats for single core metal sheathed cable carrying alternating current shall be so as to avoid the setting up of a magnetic circuit through any steel or iron work. Single core cables carrying alternating current or three cables arranged in trefoil formation with the cables touching and where departures from the trefoil formation cannot be avoided, approved arrangements shall be employed to minimise sheath currents or other undesirable effects.
 - 9.2.7.3. The cleating arrangements for single core cables shall be of the sufficient strength to withstand the forces set up during short circuit conditions. Where installed on trays, cables not provided with cleats shall be secured by heavy gauge copper or plastic coated clips or saddles at intervals of not more than 600mm, not more than 6 cables shall be embraced by one clip, and not more than two layers of cables shall be installed on one tray.
 - 9.2.7.4. All cable cleats and support must be fire proof
 - 9.2.7.5. Where installed on walls or flat surfaces, cables shall be secured by cable cleats at intervals of not more than 600mm. Every cable shall be securely supported throughout its length and at a point not more than 100mm from its termination and on vertical routes passing through a floor, immediately above the floor. Any alternative method of fixing shall be approved by the Engineer.
- 9.2.8. Cables Installed in Service Ducts and Cable Tunnels:
 - 9.2.8.1. Where installed in service ducts cables shall be installed at least 25mm clear of walls and ceilings on cable cleats. Cable cleats shall be fixed to the galvanised rolled steel cable support system at spacing to provide satisfactory cable support.
 - 9.2.8.2. Where cables emerge from a service duct and rise up a wall, a length of suitable sized galvanised steel pipe, bushed at each end shall be threaded over the cable to 450mm above floor level so positioned as to protect the cable from mechanical damage.
- 9.2.9. Fire Barriers:
 - 9.2.9.1. Where cables are routed through floors and main fire compartment walls, a system of proprietary fire barriers shall be installed by the Contractor. The fire barriers shall consist of a metal frame, complete with edge flange. After installation of the cabling, fire resisting neoprene type inserts and filler blocks shall be inserted around the cabling and the necessary stay plates, compression plates and end packing units installed. The Manufacturers recommended lubricant shall be used when packing the neoprene

inserts and filler blocks into the fire barriers. In certain circumstances, the Fire Officer may specify an alternative infill for the fire barrier.

9.3. Standards

BS 4568 : 1988	Steel conduit and fittings for electrical installations
BS 4607	Non Metallic Conduit and fittings for electrical installations
BS 6099	Conduits for electrical installations.
BS 4678	Cable trunking

9.4. Metallic Conduit and Fittings

9.4.1. Conduit Tubing

- 9.4.1.1. Unless otherwise specified, all non-armoured cables shall be installed in heavy gauge, welded steel conduit using screwed joints. In general areas all conduit shall be finished with black enamel (Class 2). In plant areas, humid atmospheres and all external installations, conduit and fittings shall be installed with a galvanised (Class 4) finish.
- 9.4.1.2. Whichever finish is adopted, either black enamel or galvanised, it shall be maintained throughout the conduit system including all fittings and accessories. A mixture of finishes will not be accepted.

9.4.2. Fittings

- 9.4.2.1. Conduits and conduit fittings/accessories shall comply with BS 31 (with amendments) and be of heavy gauge, seam welded, steel tube screwed, having a hot dip galvanised finish to BS 4568 Class 4 and BS 31 Class 4.
- 9.4.2.2. The sizes of conduits used and the number of cables installed shall be strictly in accordance with the requirements of BS7671, the smallest size being 20mm.
- 9.4.2.3. Conduit installed for the telephone system shall be installed complete with draw-in wires.
- 9.4.2.4. No bends, elbows or tees, solid or inspection type shall be used in the installation of metallic conduit unless authorised in writing by the Engineer. All bends shall be formed on site using suitable bending tools.
- 9.4.2.5. All junction boxes and draw-in boxes shall be of malleable cast iron circular type provided with a cast iron or pressed steel lid secured by brass screws. They shall be manufactured to BS 4568 Part 2.
- 9.4.2.6. Switches, socket outlets and spur units shall be mounted in galvanised pressed steel boxes suitable for conduit wiring systems.

9.4.3. Installation and Fixing of Metallic Conduit

- 9.4.3.1. Conduit installations shall be mechanically and electrically continuous throughout. Unless otherwise indicated all runs shall be either vertical or horizontal.
- 9.4.3.2. Conduits shall be installed as neatly and unobtrusively as possible.
- 9.4.3.3. Attention shall be paid to the installation of surface conduits. All corners and angles shall be neatly negotiated with vertical and horizontal runs kept straight and parallel to general building lines. No diagonal runs shall be permitted and all branches shall be taken off at right angles.
- 9.4.3.4. When concealed within concrete or floor screeds conduits shall be routed in a straight line where possible from point to point.
- 9.4.3.5. Conduit runs shall be left clear of gas or water pipes by minimum distance of 150mm.
- 9.4.3.6. Conduits crossing building expansion joints shall be fitted with expansion couplers at the position of the expansion joint. An earth wire shall be installed between the nearest conduit box at either side of the coupler. The back of the conduit box shall be drilled and tapped to a size not less than M4 and the earth connection made by means of an approved combination of terminal washer and brass screws.
- 9.4.3.7. A running coupler socket within 300mm above or below the floor on all vertical drops or pieces respectively shall be provided where conduit is cast into or passes through structural floors. Running couplers will be kept to an absolute minimum in all other instances.
- 9.4.3.8. Where conduits are installed in floors and the programme indicates that the screed is not to be applied within three days of the installation, then the conduits shall be protected by means of a haunching of a cement and sand mixture.

- 9.4.3.9. The conduit system shall be checked for mechanical damage, before the floor screed is laid. Any damaged conduit shall be replaced.
- 9.4.3.10. Standard round boxes shall be used for all intersection and outlet points, except where the conduit terminates in accessories such as lighting switches, socket outlets, etc.
- 9.4.3.11. At intersection points on multiple conduit runs, steel adaptable boxes with light steel covers (overlapping for concealed conduit work) shall be used which shall have minimum depth of one and a half times the largest conduit entry. Cables from more than one distribution board shall not enter any single adaptable box.
- 9.4.3.12. No boxes shall be provided in any position where access cannot be readily obtained. No draw-in boxes other than point boxes shall be installed in the plaster wall or ceiling surface, where the conduit work is flush, except within cupboards and switch-rooms, or where specific permission is given by the Engineer. If permission is given, each box shall be made permanently accessible and so arranged to be neatly finished, flush with the finished surface of the walls, ceilings or floors.
- 9.4.3.13. Joints in conduit runs shall be by means of screwed fittings, the threads being cut by suitable dies and screwed up tight. After each thread is cut it shall be cleaned with a wire brush and wiped with a clean cloth to remove all traces of cutting fluid or grease. The bore of the tubing shall be reamed out to remove all sharp edges and filed square.
- 9.4.3.14. Conduit shall be terminated in threaded spouts for conduit boxes or in clearance holes for adaptable boxes, switch boxes, enclosures of equipment and trunking. Where conduits terminate in clearance holes they shall be provided with a coupling, brass male bush and earth continuity washer.
- 9.4.3.15. All vice marks shall be removed from all conduits and fittings. Where the finish is damaged black enamel paint shall be applied to indoor conduit or an approved zinc rich paint to galvanised finished conduit.
- 9.4.3.16. No thread shall be exposed except at running couplers where they shall be painted with the appropriate primer and/or paint.
- 9.4.3.17. Running couplers shall be backed by a securely locked heavy gauge lock nut.
- 9.4.3.18. All couplers shall be securely tightened and care shall be taken to ensure that conduit ends do not butt.
- 9.4.3.19. Where called for within the particular specification conduit shall be concealed in floor screeds or wall finishes except where fixed to exposed steelwork. Wall chases shall accommodate the full depth of the conduit.
- 9.4.3.20. Conduit runs shall be so arranged that all wiring may be carried out and later removed from draw in box positions.
- 9.4.3.21. Draw-in boxes shall be provided at points no further apart than 9 metres and no run shall have more than two right angle bends between draw-in boxes.
- 9.4.3.22. The conduit shall be fixed by means of cast iron distance or spacer bar saddles with bars not less than 6.4mm thick except where fixed to wood in which case ordinary saddles may be used.
- 9.4.3.23. Where conduit is, or may be, in contact with any structural steelwork, an efficient and permanent metallic connection shall be made between them.
- 9.4.3.24. Fixing to beams, girders or structural metalwork shall be completed by means of approved fasteners, which do not require drilling.
- 9.4.3.25. Saddles shall be spaced at maximum intervals of 1400mm and at a distance of 225mm either side of a box. Fixings shall be applied only to concrete, brickwork, timber and breeze or tile partitions. All fixing works shall be drilled with masonry drills. Shot fired fixings will not be accepted.
- 9.4.3.26. Conduits fixed in screeds or chases which are to be rendered and plastered shall be fixed by steel crampets.
- 9.4.3.27. Countersunk screws shall be used for fixing only where special countersunk holes have been drilled or provided. Round headed screws used for all fixings shall be black japanned finish. Screw heads shall have burrs and sharp edges removed before wiring commences and all screws are to be driven into their correct depth. Box lids shall be fitted by means of brass round headed M4 screws. All such boxes shall be securely fixed by means of at least two screws such that the screw threads do not project into the box and damage cables.
- 9.4.3.28. Falls for drainage purposes shall not be provided in conduit runs nor shall pockets be formed within any conduit system in which moisture may collect. Drainage holes however shall be provided at suitable positions agreed by the Engineer.
- 9.4.3.29. Where conduit passes through any wall, floor or ceiling from a high temperature area to a low temperature area, a conduit box shall be inserted close to the wall, floor or ceiling on the high temperature side shall be filled with cold compound. A neoprene gasket shall be inserted between the lid and the base where these are galvanised.

- 9.4.3.30. The conduit system shall be tested for satisfactory electrical continuity where applicable, before plastering or screeding and before cables are drawn in. The tests shall be witnessed by the Engineer.
- 9.4.3.31. Where a conduit installation is subsequently covered by a wet applied finish, it shall be plugged with a removable material to exclude any plaster, concrete or other wet material.
- 9.4.3.32. Each conduit system shall be completed, dried out, cleaned and tested to the satisfaction of the Engineer before any cables are drawn-in. In concealed installations cables shall not be drawn-in until all plaster, screeds or other finishes have been completed.
- 9.4.3.33. Where required by the Engineer, the Contractor shall demonstrate rewireability of conduits by withdrawing a number of cables from conduits selected by the Engineer and replacing by a new cable or cables.

9.4.4. Flexible Conduit and Connection

- 9.4.4.1. Where the connection of solid conduit direct to equipment is not possible or desirable, as in the case of plant requiring adjustment or where vibration occurs, the conduit shall terminate at a position adjacent to the equipment and the wiring continued in a manner given below:-
 - Where the supply voltage is at or below 240V the wiring may be continued in suitable flexible cable of appropriate rating. The connection shall be made in a fixed socket and each end of the flexible cable shall be secured by means of gland or clamp.
 - Where the supply voltage is in excess of 240V, flexible conduit shall be used. Such conduit shall be constructed from a double layer of continuous strip wound helically, overlapping and rolled to form a deep close pitch thread. The exterior shall be sheathed with an extrusion of a low smoke and toxic fume emitting compound. A separate protective conductor shall be run inside the flexible conduit and connected to suitable terminations at each end of the flexible conduit.
- 9.4.4.2. The cable shall be a minimum of 2.5mm² (stranded conductor) unless defined otherwise by the particular specification.
- 9.4.4.3. A minimum length of 300mm and of sufficient length to allow the full range of withdrawal, adjustment or movement necessary.

9.5. Cable Trunking Systems

- 9.5.1. Steel surface cable trunking shall comply with BS 4678:1988. Trunking and associated covers shall have return edges. Captive cover fixings shall be provided to both securely fix the cover and give adequate earth continuity between the trunking body and the cover. Cover fixings shall be of the lever type operated by means of a screwdriver.
- 9.5.2. Trunking up to and including 150mm x 50mm is to be made of not less than 1.2mm sheet steel and sizes above are to be of not less than 1.6mm sheet steel.
- 9.5.3. All screws used to join trunking lengths together and to trunking accessories and equipment shall be pan head machine screws finished to be compatible with the protection class of the trunking. The ends of the screws shall not project into the cable space. Self-tapping screws shall not be used.
- 9.5.4. All trunking accessories shall be factory made and be of the same finish and metal gauge as the trunking with which they are to be used. All bends shall use accessories having internal gusseted corners to ensure that cable bending criteria is adhered to. Site made bends, sets, lids and flanges shall not be used. The finish of the trunking shall, in addition to the finish detailed in BS 4678:1988, be stove enamelled inside the trunking and cover or be galvanised as specified.
- 9.5.5. Steel surface trunking systems may form the whole or part of a circuit protective conductor. The final trunking system shall be checked to ensure that it can satisfactorily carry the current it will conduct under earth fault conditions and that it shall so remain for the life of the installation.
- 9.5.6. The cover of the trunking shall not be deemed to form part of the circuit protective conductor and shall be excluded for the purpose of calculation earth loop impedances, thermal ratings, etc.
- 9.5.7. Cable in steel surface trunking:
 - 9.5.7.1. The Contractor shall ensure that the size of the trunking system is such that the number type, size and current rating of the cables are accommodated in accordance with manufacturer's instructions and without damage to the cables and in accordance with the requirements of BS7671.
 - 9.5.7.2. The Contractor shall be responsible for determine the size and route of all trunking systems and shall obtain the Engineer's approval with respect to routes and sizes before installation commences. Trunking sizes shown on the Engineer's drawings shall be taken as notional.

- 9.5.7.3. Such trunking shall be capable of containing 50% additional cables of the average size of the conductors to be installed in the trunking.
- 9.5.7.4. Where ever practical, unless otherwise stated the Contractor shall look to use multi-compartment trunking. The method of fixing/support will be agreed with the Engineer prior to installation.
- 9.5.7.5. Where trunking is used to carry more than one service, it shall be sub-divided into separate compartments for power, telephone and auxiliary services.

9.5.8. Installation

- 9.5.8.1. Trunking shall be installed in a neat and workmanlike manner. Indication routes only are shown on the drawings and the working drawings shall reflect the final installation (and shall be co-ordinated with other services) and be approved by the Engineer. Site cutting of lengths of trunking shall be true and square. (All cut edges shall be prepared and treated with a zinc rich paint). Drilling of the trunking for couplers and earth links shall be made using a jig and all burrs from the cutting and drilling processes shall be removed and the cut edges protected to be compatible with the protection class of the trunking.
- 9.5.8.2. where plastic containment is used then non-combustible supports must be provided / used and the provided support should be in line with 521.11.201 to minimise premature collapse of cables.
- 9.5.8.3. Electrical continuity across all joints tunnel in the trunking system shall be ensured by the use of the propriety copper earthing links. Where trunking with a stove enamel finish is specified the enamel shall be carefully removed under the area of the screws securing the link.
- 9.5.8.4. Trunking covers shall be cut square and where necessary cut for the installation of trunking cover fixing accessories. All burrs shall be removed and the cut edges protected to be compatible with the protection class of the trunking. Covers shall be installed with the trunking installation and shall butt closely together. Each cover piece shall be fixed in at least two places along its length. The distance between cover fixings on each cover shall not be more than 1000mm. Trunking covers shall be completely removable throughout its entire length, and shall be supplied in lengths no greater than 2m.
- 9.5.8.5. Every length of trunking and every trunking accessory shall be independently fixed to the structure of the building by pan head or round head screws finished to be compatible with the protection class of the trunking.
- 9.5.8.6. Connections between trunking and equipment shall be made via a standard flanged connector, such as screwed conduit coupler and male hexagon brass bush or such other arrangement agreed with the Engineer.
- 9.5.8.7. All arrangements shall present a smooth path for the passage of cables.
- 9.5.8.8. Adjoining sections of trunking shall bolt tightly and shall be joined by means of an internal fish plate connection, attached by means of steel bolts, passing through clearance holes.
- 9.5.8.9. Where connection is made between trunking and distribution board the cable entry shall be sized to accept cables from both used and spare ways. Holes in trunking shall be neatly drilled with a drill or hole saw and all edges smoothed with a file and painted with zinc rich paint.
- 9.5.8.10. Cable retaining straps or springs shall be installed at 450mm centres throughout the length of the trunking. In all vertical runs and in horizontal runs of trunking where the vertical dimension of the trunking is 100mm or more pin racks shall be installed at 1200mm centres or less to provide support for the cables.
- 9.5.8.11. Where trunking passes through floors and walls a fixed length of cover which projects 75mm on either side of the floor or wall shall be provided. Where the floor or wall forms a fire barrier the trunking shall be packed with glass wool for the length of the fixed cover. Trunking systems shall be installed with at least 150mm clearance from other fixed metalwork including pipes and ducts associated with other building services.
- 9.5.8.12. Where trunking passes through fire barriers, walls or floors, delineating a fire compartment of the building the trunking shall be provided with internal fire barriers in accordance with the requirements of BS 7671 and as directed by the Architect.
- 9.5.8.13. Where trunking passes from a normally heated to an unheated area, a barrier shall be provided within the trunking to prevent air convection currents and consequent condensation within the trunking.
- 9.5.8.14. Any brackets or supports required for trunking systems shall, unless stated otherwise, be regarded as part of the trunking system together with their fixings. Brackets and supports shall be finished to give the same degree of protection as the trunking system supported.
- 9.5.8.15. No trunking system shall comprise components finished to more than one class. Where the finishes of trunking systems have been damaged they shall be made good to give the same degree of protection as

when new. The making good shall be carried out within twenty four hours of the trunking being installed. The contractor shall allow for the installation of the fire barriers as appropriate.

9.5.8.16. Trunking shall be positioned so that adequate clearance is provided for access to the wiring.

9.5.9. Plastic (uPVC) Trunking

9.5.9.1. Plastic (uPVC) trunking will only be used when authorised by the Engineer. In general flame retardant materials will be used throughout, which will be of the halogen free self-extinguishing type. All trunking will comply as a minimum with the UL 94 VO flammability rating.

9.5.9.2. Trunking is to be manufactured from extruded polyvinyl chloride of sufficient thickness to prevent "whipping".

9.5.9.3. Covers are to be of the same gauge as the trunking and shall have turned edges to overlap the trunking body.

9.5.10. Plastic Trunking

9.5.10.1. The same methods of fixing will be used as for both steel and plastic trunking. The use of adhesive pads will not be permitted. Where advised by the Manufacturer, adjoining length of trunking will be glued together using the manufacturer's approved adhesive. Fixing centres in excess of 1m will not be permitted.

9.5.10.2. Wherever practical, manufactured bends, tees etc. will be used. Where this is not possible, all site manufactured items will be subject to the approval of the Engineer. Units that fail to meet the required standard will be replaced at the Contractors cost. Where dedicated trunking is being used, all bends, tees etc. will be produced by the Manufacturer at his works. No on-site fabrication will be permitted. The Contractor will allow surveying the works to provide the manufacturer with the required information.

9.5.10.3. Expansion joints are to be fitted at not more than 15m intervals in straight lengths of trunking.

9.5.10.4. Wiring will be installed as per sub-circuits installed in steel trunking systems. A separate CPC will be installed with all sub-circuits. Capacities will be as defined by the manufacturer's instructions and in accordance with the requirements of the latest version of BS7671.

9.6. Cable Tray Systems

9.6.1. Perforated metal cable tray shall be formed from plain sheet steel complying with BS 1449: Part 18, classification HR4/GP and hot dipped galvanised to BS EN ISO 1461 unless other types of finish are specified within the particular specification.

9.6.2. Where defined within the particular specification the cable tray shall be manufactured to one of the following returned flange configuration.

- Standard return flange 25mm deep
- Medium duty flange 50mm deep
- Heavy duty flange 80mm deep

9.6.3. The perforated cable tray shall be formed from plain sheet steel and each cable tray shall be manufactured from the following minimum gauge steel:-

Width	Gauge
102mm	1.0
152mm	1.0
229mm	1.0
305mm	1.6
457mm	1.6
610mm	1.6
762mm	1.6

9.6.4. Cable tray shall only be cut along a line of plain metal, i.e.; not through the perforations. All cut edges of galvanised cable tray shall be prepared and treated with a zinc rich paint. Site fabrication of accessories

shall be kept to a minimum and manufacturer's standard items shall be used. Where special sections are required, the material, thickness and finish shall be as specified for standard items.

- 9.6.5. Where welding has been employed in the fabrication of cable tray and/or accessories, the area around the joint shall be mechanically prepared and thereafter treated with zinc chromate primer or zinc rich paint according to the original finish of the metal. Holes cut in cable tray for the passage of cables shall be provided with grommets complying with BS 1767: 1951. Alternatively, they shall be bushed or lined.
- 9.6.6. A minimum clear space of 20mm shall be left behind all cable tray for securing cable ties. Supports for cable trays shall be disposed at regular intervals not exceeding 1200mm and at 225mm from bends and intersections. The maximum deflection of cable tray will not exceed 5mm through its entire length.
- 9.6.7. Where cables enter or leave cable trays, the Contractor shall ensure that no sharp edges are carrying the weight of cables and that no cables subject to vibration are in a position where they could be abraded by the cable tray.
- 9.6.8. Bends:
 - 9.6.8.1. Bends shall be of the same material, thickness and finish as the cable tray and shall have an inner radius to suit the bending radius of the cable and a straight length of 100mm at each end. No perforations shall be made in the circular portion of 100mm and 150mm bends. On 225mm and 300mm bends perforations shall be made only along a line set at 45 degrees. On 450mm and 600mm bends perforations shall be made only along lines set at 30 degrees and 60 degrees.
- 9.6.9. Tees:
 - 9.6.9.1. Tees shall be of the same material, thickness and finish as the cable tray. The distance measured between a point of intersection and the end of the fitting shall be 100mm.
- 9.6.10. Fixing Screws:
 - 9.6.10.1. Mushroom-head steel roofing bolts and nuts complying with BS 1494: Part 1:1964, shall be used to fix together adjacent sections of cable tray and/or accessories.
- 9.6.11. Supports:
 - 9.6.11.1. Cable tray shall be supported at centres not exceeding 1200mm, using galvanised channel steel brackets spaced from the fabric of the building or suspended from threaded rods using proprietary fixings onto the structural steelwork or other structural member. No supports shall be from other containment systems, pipe brackets or similar supporting systems.

9.7. Cable Ladder Rack Systems

- 9.7.1. Cable ladder rack shall be formed from plain sheet steel complying with BS 1449 Part 1B classification and hot dipped galvanised to EN ISO 1461, unless other types of finish are specified within the particular specification.
- 9.7.2. Unless defined within the particular specification the cable ladder shall be manufactured to have a heavy duty 50mm minimum flange.
- 9.7.3. The cable ladder shall be manufactured with a minimum of 2mm thick gauge steel.
- 9.7.4. The cable ladder system shall be generally in accordance with the requirements specified for cable tray systems using purpose made manufactured fittings and bends.
- 9.7.5. The Contractor shall adhere to any manufacturers' recommendations regarding expansion joints.
- 9.7.6. When full loaded the cable ladder system shall not deflect more than 5mm between any two supports along its entire length.
- 9.7.7. The entire cable ladder system and accessories shall be from one manufacturer.

9.8. Underfloor Cable Trunking Systems

- 9.8.1. The Contractor shall install an underfloor cable trunking system when detailed in the particular specification and or indicated on the drawings.
- 9.8.2. The underfloor cable trunking system shall be manufactured to BS 4678: part 2 comprise of heavy gauge galvanised sheet steel and be suitable for placing on structural floors.
- 9.8.3. The Contractor shall adhere to the manufacture recommendations regarding the number of fittings required in order to secure the trunking body to the structural floor.
- 9.8.4. The trunking shall be installed complete with all junction boxes crossover dividers and cast iron or heavy duty steel covers. Covers shall be provided suitable for accepting the floor finishing and or covering.

- 9.8.5. The height of the cover frames shall be adjustable to suit variations in screed depth.
- 9.8.6. The under floor trunking system shall be provided with service outlet boxes in the location indicated on the drawings, complete with hinged covers suitable for accepting the floor finish or covering. Covers must be complete with grommeted cable outlets and supported by adjustable cover frames to suit variations in screed depths.
- 9.8.7. The Contractor shall be responsible for liaising with the main Contractor to ensure that levelling and alignment of the trunking system is carried out to an agreed floor finish level.
- 9.8.8. Where indicated on the drawings the underfloor trunking system shall provide conduit connections at junction boxes to facilitate spurring off to individual accessories.
- 9.8.9. The entire trunking system shall be cleared of all builders' debris and or foreign bodies prior to wiring of the trunking system.
- 9.8.10. Intermediate boxes and junctions shall have gussets or rounded corners although the lids may be square.
- 9.8.11. The entire underfloor trunking system shall be bonded to the general earth with metal earth tags fixed at every joint and or termination within the trunking body floor outlet boxes shall be bonded to the trunking body by means of a separate green and yellow 2.5mm² cable adequately lugged at each end.

9.9. External Ducts and Draw Pits

- 9.9.1. Where installed in open ground, cables will be directly buried in accordance with the following:
 - 9.9.1.1. LV cables in uncultivated open ground, footpaths and pavements.
 - Cables shall be laid on a 75mm thick sand bed and covered with 75mm thick layer of sand.
 - Interlocking clay or concrete tiles marked "DANGER ELECTRICITY" shall be laid on the sand to cover the cables.
 - The tiles shall be covered with a 300mm thick layer of hand-placed, selected backfill, with no hardcore, well rammed.
 - One or more continuous plastic marker strips, marked "DANGER ELECTRICITY" shall be laid on this layer to effectively cover the area of the cables.
 - The trench shall be back filled with excavated material to give a minimum cover of 600mm.
 - 9.9.1.2. HV cables in Uncultivated Open Ground, Footpaths and Pavements.
 - Cables shall be laid on a 75mm thick sand bed and covered with 75mm thick layer of sand.
 - Interlocking clay or concrete tiles marked "DANGER ELECTRICITY" shall be laid on the sand to cover the cables.
 - The tiles shall be covered with a 300mm thick layer of hand-placed, selected backfill, with no hardcore, well rammed.
 - One or more continuous plastic marker strip, marked "DANGER ELECTRICITY" shall be laid on this layer to effectively cover the area of the cables.
 - The trench shall be back filled with excavated material to give a minimum cover of 800mm.
 - 9.9.1.3. LV Cables in Soft Landscape Area
 - Cables shall be laid on a 75mm thick sand bed and covered with 75mm thick layer of sand.
 - Interlocking clay or concrete tiles marked "DANGER ELECTRICITY" shall be laid on the sand to cover the cables.
 - The tiles shall be covered with a 300mm thick layer of hand-placed, selected backfill, with no hardcore, well rammed.
 - One or more continuous plastic marker strip, marked "DANGER ELECTRICITY" shall be laid on this layer to effectively cover the area of the cables.
 - The trench shall be backfilled with clean top soil with all stones above 25mm removed to give a minimum of 600mm.
 - 9.9.1.4. HV cables in Soft Landscape Areas.
 - Cables shall be laid on a 75mm thick sand bed and covered with 75mm thick layer of sand.
 - Interlocking clay or concrete tiles marked "DANGER ELECTRICITY" shall be laid on the sand to cover the cables.
 - The tiles shall be covered with a 300mm thick layer of hand-placed, selected backfill, with no hardcore, well rammed.

- One or more continuous plastic marker strip, marked "DANGER ELECTRICITY" shall be laid on this layer to effectively cover the area of the cables.
- The trench shall be backfilled with clean top soil with all stones above 25mm removed to give a minimum cover of 800mm.

9.9.2. Where installed under roadways, under and into buildings, under walls and structures and in any position where late excavation may be unduly difficult, be installed in 150mm diameter earthenware or pitch fibre ducts. Only one cable shall be installed in each duct. The duct shall be installed in accordance with the following:-

9.9.2.1. Ducts for LV Cables in Roadways:

- Ducts shall be laid on 100mm thick bed of 10mm single size granular material and covered with a 100mm layer of the same material. This layer shall then be covered with a 100mm layer of selected fill.
- One or more continuous plastic marker strip marked "DANGER ELECTRICITY" shall be laid on the selected fill to effectively cover the area of the ducts.
- The trench shall be backfilled and hand compacted in 150mm layers and finally made up to finished roadway level in accordance with the roadway specification to give a minimum cover of 800mm.

9.9.2.2. Ducts for HV labels in roadways

- Ducts shall be laid on 100mm thick bed of 10mm single-size granular material and covered with a 100mm layer of the same material. This layer shall then be covered with a 100mm layer of selected fill.
- One or more continuous plastic marker strips marked "DANGER ELECTRICITY" shall be laid on the selected fill to effectively cover the area of the ducts.
- The trench shall be backfilled and hand compacted in 150mm layers and finally made up to finished roadway specification to give a minimum cover of 1000mm.
- All ducts containing a cable shall be sealed at each entry by means of a split wooden bung bored out to the cable diameter, a layer of "Denso Mastic (Plast)" and a final seal of poured bitumen compound.
- All unused ducts shall be sealed at each entry by means of a wooden bung and a layer of "Denso Mastic (Plast)". A minimum of 100% spare ducts shall be installed.
- All ducts will be fitted with nylon draw wires.
- Where the minimum duct cover specified cannot be achieved the ducts shall be haunched and covered with mass concrete.

9.9.3. The following minimum horizontal clearances shall be maintained:-

- Between LV cable and LV cable - 150mm.
- Between LV cable and HV cable - 300mm.
- Between HV cable and HV cable - 300mm.
- Between LV cable and Telephone cable - 450mm.
- Between HV cable and Telephone cable - 800mm.

9.9.4. Ducts will have their routes marked by means of cable markers. Cable markers shall be installed in accordance with the following:

- At each side of each road crossing.
- At each change of direction.
- At each point where cables pass into or under a building or structure.
- At each joint.
- At intervals not exceeding 45m on straight runs.

9.9.5. All markers shall be pre-cast concrete with engraved plastic labels and shall be firmly set in concrete. Labels shall be engraved with:-

- Cable reference or identification.
- Service Voltage.
- Cable type and size.

- Depth below ground.
- 9.9.6. Ducts will have each run of cable installed, covered with sand and cable tiles, as specified, in one continuous operation so as to be completed within one working day. Trenches shall be back-filled, as specified, within 72 hours of the commencement of installation of the cables. Where difficulties are foreseen in meeting these requirements then with the prior approval of the Engineer, the work may be sectionalised.
- 9.9.7. Cables will be installed when the air temperature is above 0 deg. C and has been above the temperature for at least the previous 24 hours.
- NB: Where any of the following conditions are encountered on site the Contractor shall refer to the Engineer before putting that section of work in hand:
 - Waterlogged ground or running water
 - Steeply sloping sections.
 - Substantial quantities of ashes or decomposing material.
 - Running sand, voids, soft spots or parts liable to subsidence.
- 9.9.8. Where cable ducts are installed in situations having little or no open ground, then draw-in pits shall be provided in accordance with the following:
- At each significant change of direction.
 - At intervals not exceeding 20m in straight runs.
 - Where otherwise required to facilitate drawing in.
- 9.9.9. Draw-in pits shall be constructed in accordance with the following;
- Cover and Frame: - as specified by the Architect or Civil Engineer.
 - Brickwork: - 225mm thick class "B" engineering bricks to BS 3921: 1985 without perforations, English bond, 1:3 mix cement mortar.
 - Base: - 200mm thick concrete 25N/mm² (grade 25) with 25mm top cover to reinforcement of Y10 at 150mm centres in both spans with bent ends. Base to be cast on 50mm concrete blinding. The base shall overlap the brickwork by a minimum of 150mm all round.
 - Duct entries shall be arranged to give the maximum possible cable radii.
- 9.9.10. Unless otherwise detailed within the particular specification the Contractor shall be responsible for:
- Marking out the routes of all cables on site.
 - Supplying all conduits/ducts.
 - Instructing and supervising the Main Contractor with regard to excavation work and the installation of ducts and draw-in pits.
 - Supplying and installing all cables.
 - Instructing and supervising the Main Contractor with regard to the placing of sand.
 - Supplying and laying cable tiles.
 - Supplying and laying marker tape.
 - Instructing and supervising the Main Contractor with regard to back-filling.
 - Supplying all cable markers.
 - Instructing and supervising the Main Contractor with regard to installing cable markers.
 - Sealing all ductways.
 - Recording route details of all cables installed.
 - Note: where not subject to a sub-contract the Electrical Contractor shall be responsible for the whole of the work specified.

9.10. Routes and Segregation

- 9.10.1. The routes of conduit, trunking and ducting shall be determined by the Contractor and approved by the Engineers prior to commencement of installation.
- 9.10.2. 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.

- 9.10.3. 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. Deviation from this will be subject to approval from the Engineer.
- 9.10.4. A minimum clearance of 150mm shall be allowed from any equipment, pipework or ductwork. The distance shall be measured from the external surface of any lagging.

10. LUMINAIRES

10.1. General

- 10.1.1. The installation shall include all lamps, wiring, switches, contactors, controller supports and fixings necessary to complete the works as defined within the particular specification and drawings.
- 10.1.2. Unless otherwise specified, all luminaires shall be supplied and installed by the Contractor in accordance with the schedules. Each luminaire shall be rigidly supported.
- 10.1.3. Luminaires shall comply with BS 4533:1990 and BS EN 60598, and shall meet the requirements of the Electromagnetic Compatibility Regulations 1989. Furthermore they shall in their design and manufacture allow compliance in both operation and maintenance with the Electricity at Work Regulations 1989.
- 10.1.4. Where luminaire forms part of the ceiling, the contractor shall ensure a diffuser TPa/TPb rating in accordance with building regulations.
- 10.1.5. All luminaires which are to be mounted in direct contact with the building fabric shall achieve an "F" rating in accordance with BS 4533.
- 10.1.6. All luminaires shall be earthed and have an efficacy of at least 90lm/cw
- 10.1.7. Unless otherwise indicated the enclosure of luminaires shall provide a minimum degree of protection of IP22 when located within buildings and IP54 when located externally.
- 10.1.8. Simple means shall be provided for the removal of diffusers for lamp replacement, and lamp holders arranged so that a lamp can easily be removed and replaced by one operative.
- 10.1.9. The control gear for discharge lamps, including fluorescent tube luminaires shall be effectively suppressed against radio interference and the circuit power factor shall not be less than 0.9 lagging.
- 10.1.10. The Contractor shall note the necessity of testing luminaires before erection since no extra labour charges or otherwise will be allowed for taking down, refixing etc., luminaires and lamps found to be faulty after erection.

10.2. Luminaire Construction

- 10.2.1. All materials, accessories and other related fitting parts shall be new and free from defects which may in any manner impair their character, appearance, strength, durability and function, and effectively protected from any damage from the time of fabrication to the time of delivery and until final acceptance of the work.
- 10.2.2. All luminaires shall be designed and manufactured, and all materials selected to provide a working life, of 20 years.
- 10.2.3. All intersections and joints shall be formed true and of adequate strength and structural rigidity to prevent any distortion after assembly.
- 10.2.4. Housings shall be so constructed that all electrical components are easily accessible and replaceable without removing fittings from their mountings, or disassembly of adjacent constructions.
- 10.2.5. All lamp sockets in luminaires shall be suitable for the indicated lamps and shall be set so that lamps are positioned in the optically correct position.
- 10.2.6. All luminaires shall be completely wired at the factory.
- 10.2.7. If ceiling system requires, each recessed and semi-recessed luminaire shall be furnished with a mounting frame or ring compatible with the ceiling in which they are to be installed. The frames and rings shall be one-piece or constructed with electrically welded butt joints, and of sufficient size and strength to sustain the weight of the fitting.
- 10.2.8. Light leaks between ceiling trims of recessed luminaires and the ceilings will not be tolerated. If the luminaire is used in partially transparent ceiling, light leaks above the ceiling line will not be tolerated.
- 10.2.9. Yokes, brackets and supplementary supporting members needed to mount luminaires to carrier channels or other suitable ceiling members shall be furnished and installed by the Contractor.
- 10.2.10. Fittings for use outdoors or in areas designated as damp locations shall be suitably gasketed to prevent the ingress of moisture. Approved wire mesh screens for ventilation openings shall be provided.

- 10.2.11. For steel and aluminium fittings, all screws, bolts, nuts and other fastenings shall be cadmium or equivalent plated. For stainless steel fittings, all fastenings shall be stainless steel. For bronze fittings, all fastenings shall be stainless steel or bronze.
- 10.2.12. All luminaires and ballasts must operate within the temperature limits of their design and as specified by British Standards Institute in the applications and mounting conditions herein specified.

10.3. Reflectors and Trims

- 10.3.1. Reflectors, reflector cones and visible trim of all luminaires shall not be installed until completion of plastering, ceiling tile work, painting and general clean-up. They shall be carefully handled to avoid scratching or finger-printing and shall be, at the time of acceptance by the Client, completely clean.
- 10.3.2. All anodised parabolic cones shall be guaranteed against discolouration for a minimum of ten years, and, in the event of premature discolouration, shall be replaced by the manufacturer, including both the cost of materials and the cost of labour.
- 10.3.3. Aluminium reflectors shall be anodised finished specular, semi-specular, or diffuse as required.
- 10.3.4. As such the aluminium surface shall be treated to prevent iridescence. The finish shall be robust and capable of withstanding the design life recommended maintenance for removal and cleaning.
- 10.3.5. Plastic used for lenses and diffusers shall be formed of colourless material. Plastic lenses and diffusers shall be properly cast, moulded or extruded as specified, and shall remain free of any dimensional instability, discolouration, embrittlement, or loss of light transmittance for at least 15 years.
- 10.3.6. All diffusers and lenses shall comply with the requirements of the Building Regulations regarding flammability and spread of flame.
- 10.3.7. Polystyrene shall not be used.
- 10.3.8. Glass used for lenses, refractors and diffusers in incandescent luminaires shall be tempered for high impact and heat resistance; the glass shall be crystal clear in quality.
- 10.3.9. Prismatic diffusers shall have the prisms located on the internal surface of the diffuser to minimise the build-up of dirt and aid cleaning of the external surface.
- 10.3.10. For exterior luminaires, use tempered borosilicate glass. For luminaires directly exposed to the elements and aimed above the horizontal with a radiant energy of 6443 watts per square metre or greater, use glass approved in BS 4533.
- 10.3.11. Where optical lenses are used, they shall be free from spherical and chromatic aberrations and other imperfections which may hinder the functional performance of the lenses.
- 10.3.12. All lenses, louvres, or other light diffusing elements shall be removable, but positively held so that hinging or other normal motion will not cause them to drop out.
- 10.3.13. The method of attaching the diffuser/louvre to the body shall provide support during the installation/removal sequence.
- 10.3.14. All lenses shall be turned over to the Client, clean and free of dust.

10.4. Supports and Fixings

- 10.4.1. Fixing arrangements shall be sufficiently strong to ensure that the mechanical and electrical safety of the luminaires is not impaired by a reasonable additional load inadvertently imposed in the luminaires during installation or use.
- 10.4.2. Luminaires shall not be supported from ductwork, pipework or mechanical services.
- 10.4.3. Where luminaires are suspended from the structural slab they shall be supported by conduit or drop rods where necessary. All supports shall be straight and vertical and shall have 40mm threaded end for screw adjustment levelling. A minimum of four supports shall be provided for modular luminaires. A minimum of two supports shall be provided for linear type luminaires.
- 10.4.4. Threaded rod suspension shall comprise 6mm or 10mm zinc plated steel, and shall be selected to provide a carrying capacity of not less than twice the weight of the complete luminaire.
- 10.4.5. Washers, nut and lock nut shall be provided top and bottom of rod. All cut ends shall be painted with Zinc rich paint.
- 10.4.6. Where 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.
- 10.4.7. Where the weight of a luminaire is supported by a conduit box or trunking it shall be adequate for the purpose.

- 10.4.8. Where luminaires are supported from cable trunking they shall do so by means of proprietary clamps or brackets. All trunking utilised for this purpose shall be mechanically suitable for this application and installed in accordance with the manufacturers recommendations.
- 10.4.9. Luminaires shall not be supported directly from conduit boxes and trunking made from non-metal or heat sensitive materials, where the temperature of the material may exceed 60oC or the suspended weight exceeds 3kg.
- 10.4.10. Luminaires shall be installed as indicated upon the drawings, and in a horizontal plane unless indicated otherwise.
- 10.4.11. Recessed luminaires shall be installed flush with the finished ceiling level.
- 10.4.12. All luminaires shall be installed in accordance with the manufacturer's recommendations.
- 10.4.13. The appropriate classification of luminaires shall be utilised, however, no luminaires shall be mounted on flammable surfaces.
- 10.4.14. Pendant luminaires shall be suspended at a height of 2050 mm above finished floor level, measured to the lowest part of the luminaire, unless otherwise stated.
- 10.4.15. A pendant shall comprise a ceiling rose, flexible cord and lamp holder.
- 10.4.16. Unless otherwise stated, the flexible cord shall be 0.75mm² with 85 degrees C heat-resisting PVC insulation. Where the lamp holder has a metal exterior, the flexible cord shall include a protective conductor connected to the earthing terminal of the lamp holder and of the ceiling rose.
- 10.4.17. 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 conduit entry to the luminaire, a backnut shall be used.
- 10.4.18. 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 supported.

10.5. Electrical Connections to Luminaires

- 10.5.1. In all instances where cables enter luminaires through a hole in the body an appropriately sized grommet, bush or gland shall be used.
- 10.5.2. Terminal blocks for connection of the supply cables shall be adequate for the size of the conductors forming the loop-in wiring specified.
- 10.5.3. Each incoming terminal shall be marked to identify each conductor of each circuit.
- 10.5.4. A fuse holder and BS 1362 fuse shall be included within each incoming circuit phase connection. The fuse shall be rated as recommended by the manufacturer.
- 10.5.5. Where remote control gear is utilised it shall be installed within a separate steel enclosure providing the same degree of protection and finish specified for the luminaire. Maximum cable lengths between gear and lamp as recommended by the manufacturer shall be strictly adhered to.

10.6. Final Connections to Luminaires

- 10.6.1. For surface mounted fluorescent lamp luminaires fixed to conduit boxes or trunking the wiring shall be taken direct to the terminal block within the luminaire.
- 10.6.2. Where luminaires are suspended, recessed into the suspended false ceiling or mounted upon the suspended false ceiling, the conduit shall terminate adjacent to the luminaires on the soffit, slab or roof construction in a 2 amp, 3 pin plug in ceiling rose and cover assembly, complete with plug.
- 10.6.3. Where connections to self-contained emergency luminaires are required, 4 pin plugs shall be utilised where the fourth pin is used for the unswitched permanent supply.
- 10.6.4. The final connection between high pressure discharge or fluorescent lamp luminaires and the 2 amp plug in ceiling rose described above shall be by means of heat resisting flexible cord. Flexible cords used for final connections to luminaires shall be 2m length unless otherwise specified.
- 10.6.5. Luminaires connected by flexible cord shall be earthed by means of an additional earth conductor within the flexible cord. The earth terminal of the plug in ceiling rose shall have a cable connection to an earth stud within the conduit box or trunking as appropriate.
- 10.6.6. Luminaires mounted directly upon conduit boxes shall have an earth cable connection between the earthing terminal of the luminaire and an earth stud within the conduit box.

10.7. Standards

10.7.1. The luminaires shall comply with the following standards. This list is not exhaustive.

- BS 2782: Method of testing plastics.
- BS EN 60598
- BS 764: Specification for automatic change-over contactor for emergency lighting systems.
- BS EN 60081: Tubular fluorescent lamps for general
- BS 1853: Part 2: Lighting service.
- BS 3772:1994, EN 60155: Specification for starters for fluorescent lamps.
- BS 7671: Requirements for electrical installations
- BS EN 61049: Specification for capacitors for use in fluorescent and other discharge lamp circuits.
- BS EN 61048: Specification for capacitors for use in tubular fluorescent and discharge lamp circuits.
- BS 5225: Photometric data for luminaires.
- BS 5266: Emergency lighting code of practice
- BS EN 60400: Specification for lamp holders for tubular fluorescent lamps and starter holders.
- BS EN 60920: Specification for ballasts for tubular fluorescent lamps – performance requirements.
- BS EN 60928: Specification for AC supplied electronic ballasts for tubular fluorescent lamps general and safety requirements.
- BS EN 60924: Specification for general and safety requirements for D.C supplied electronic ballasts for tubular fluorescent lamps.
- BS EN 60925:1991: Specification for performance requirements for D.C supplied electronic ballasts for tubular fluorescent lamps.
- BS 4800:2011: Schedule of Paint colours for building purposes.
- PR EN 50 081-1: CENELEC draft standard for EMC Emission.
- PR EN 50 082-2: CENELEC draft standard for EMC Immunity.
- European Directive: 89/336/EEC for electromagnetic compatibility.
- BS EN 12464-1:2011 Lighting of Workplaces

10.8. LED Luminaires

- 10.8.1. Luminaires shall have a lamp lumen maintenance factor of a least L80 for 50'000 hours, a minimum CRI of 80 and an efficacy of at least 0.9 l/CW.
- 10.8.2. LED module control gear shall provide a ± 3 percentage continuous output current and have an efficiency of at least 90 percent.
- 10.8.3. LED driver shall provide a minimum nominal life expectancy of 100'000h
- 10.8.4. All LED control gear shall comply with BS EN62384.
- 10.8.5. Unless specified otherwise, all LED chips shall emit a colour temperature of 4000K.
- 10.8.6. The contractor shall ensure that all recessed luminaires use diffusers with a TP(a)/ TP(b) rated material.

10.9. Spares

- 10.9.1. The Contractor shall allow for 10% of each type of lamp installed as spares.
- 10.9.2. The spares shall be tested prior to being handed over to the client's representatives to ensure that they are in good working order.

10.10. Special Applications

- 10.10.1. Emergency luminaires shall comply with BS 4533. In addition, they shall also comply with ICEL:1001 and shall be marked with an ICEL certification label.
- 10.10.2. They shall also comply with the detailed requirements set out within Section 16 of this specification.
- 10.10.3. Emergency exit signs shall comply with BS 5499 Parts 1 and 3
- 10.10.4. High voltage electric signs and luminous discharge tube installations shall comply with BS 559:1991.
- 10.10.5. Luminaires for use within potentially explosive atmospheres shall comply with BS 5345.
- 10.10.6. Street lighting columns shall be constructed and installed in accordance with BS 5469 and BS EN 40-1:1991. Columns set within the ground shall be fitted with a base plate unless indicated otherwise.
- 10.10.7. 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 HRC BS 88 fuses. Control equipment shall be incorporated as required.

11. EMERGENCY LIGHTING SYSTEMS

11.1. General

- 11.1.1. Emergency lighting systems shall be installed as described within the particular specification.
- 11.1.2. The systems are intended to provide temporary illumination to escape routes, walkways, selected areas and signage by means of separate, self-powered lighting in the event of failure of the normal lighting system.
- 11.1.3. The emergency lighting systems shall utilise self-contained luminaires, maintained, or non-maintained category as appropriate,.
- 11.1.4. All luminaires and associated equipment shall be ICEL approved and conform to the following British Standards.

11.2. Standards

- 11.2.1. The emergency lighting equipment shall be designed, constructed and tested in accordance with the following British Standards and IEC publications as they apply.
- 11.2.2. This list is not exhaustive.
 - BS 764: 1990 - Automatic change over contactors for emergency lighting systems.
 - BS 5266: Part 1 : 1988 - Emergency lighting - code of practice for the emergency lighting of premises other than cinemas and certain other specified premises used for entertainment.
 - BS 5266 Part 3 : 1981 - Emergency lighting - specification for small power relays (electromagnetic) for emergency lighting applications up to and including 32A.

11.3. Types of Systems

- 11.3.1. Where called for within the particular specification the Contractor shall supply, install, test and commission the following systems:
- 11.3.2. Central Battery System
 - 11.3.2.1. Static Inverter Type, 240v A.C.
 - 11.3.2.2. The static inverter type system shall be capable of supplying a load at 240 volts AC for the duration of not less than 3 hours, unless otherwise defined within the particular specification.
 - 11.3.2.3. Non-maintained, maintained and floating, 110v D.C.
 - 11.3.2.4. The central battery type system shall be capable of supplying a load at 110 volts DC for the duration of not less than 3 hours, unless otherwise defined within the particular specification.
- 11.3.3. Self-Contained Luminaires
 - 11.3.3.1. Non-maintained, maintained and sustained.
 - 11.3.3.2. The integral D.C. batteries and inverter unit shall be capable of supplying a load for the duration of not less than 3 hours, unless otherwise defined within the particular specification.

11.4. Central Battery Systems

- 11.4.1. Construction
- 11.4.2. The equipment shall be constructed in accordance with ICEL 1001 Part 1, BS 5266 and the BS EN IEC 55014-1:2021.
 - 11.4.2.1. The equipment shall be designed to operate in an ambient temperature not exceeding 30°C and a relative humidity not exceeding 80%.

11.5. Luminaires

- 11.5.1. General
 - 11.5.1.1. All emergency luminaires, both central battery slave and self-contained type shall comply with BS 5266: Part 1 and the industry Standard ICEL : 1001 and be marked with the ICEL certification label.
- 11.5.2. Self-Contained Luminaires
 - 11.5.2.1. The luminaire will provide three hours of illumination under mains failure.
 - 11.5.2.2. These shall be fully self-contained, incorporating all parts associated with the luminaire. Luminaire housings shall be constructed from a metal or other flame retardant self-extinguishing material. All batteries shall be sealed nickel cadmium, suitable for giving a minimum battery life of 5 years with an

ambient temperature of 25 deg C. All luminaires shall incorporate a high intensity red L.E.D. indicator, to monitor the supply and battery condition. Unless otherwise specified luminaires shall be suitable for 240 volt, 50 Hz operation.

11.5.3. Integral Battery Packs

- 11.5.3.1. Shall be installed to convert a standard luminaire into an emergency lighting luminaire. This shall be achieved by either:-
- 11.5.3.2. Illumination of the main lamp under supply failure conditions.
- 11.5.3.3. Illumination of a separate lamp under supply failure condition of the main lamp.
- 11.5.3.4. The battery pack shall normally be incorporated within the body of the main luminaire, either by the luminaire manufacturer or the Contractor. In instances where remote battery packs are required, interconnecting wiring shall not exceed 1500mm and shall be carried out in 1.5 sq. mm MICC cable with white LSF sheath. Remote battery pack enclosures shall be of metal construction.
- 11.5.3.5. A high intensity red LED indicator shall be incorporated within the main luminaire to monitor the supply and battery condition. This indicator shall be installed so as to be clearly visible without dismantling any part of the luminaire. The exact position of indicators shall be agreed with the Engineer prior to manufacture or installation.
- 11.5.3.6. All batteries shall be sealed nickel cadmium, suitable for giving a minimum battery life of 5 years and provide three hours of illumination under mains failure.
- 11.5.3.7. Unless otherwise specified, luminaires shall be suitable for 240 volt, 50 Hz operation.

11.6. Testing and Commissioning

- 11.6.1. The Contractor shall provide the routine and type test certificates for the emergency lighting cubicle. The tests shall be those listed in the relevant standards.
- 11.6.2. Routine tests shall be carried out on all switchgear/components as specified in the relevant standards. These tests shall not be limited to the following.

- Charger
- Output voltage and current
- Charging tests to demonstrate its capability to meet requirements in this section of the specification.
- Full functional tests.
- Batteries
- Charge/discharge tests
- Voltage Output
- Capacity tests.
- Complete functional tests all systems
- The above tests will be completed at works prior to acceptance. The Contractor shall allow to fully commission the system once complete on site.

11.6.3. Duration Testing

- 11.6.3.1. All batteries associated with the respective emergency lighting system shall be rated to achieve the required duration period as specified. The Contractor shall allow to fully charge/discharge the batteries a minimum of six times, in order to allow the cells to develop their full charge potential. The system shall be demonstrated to the Engineer for the full duration period after the foregoing charge/discharge tests have been carried out.

12. PUBLIC ADDRESS SYSTEMS

12.1. General

- 12.1.1. Unless otherwise defined within the particular specification the Contractor shall install a type 2 system as defined by BS 6259 except certain areas (plantrooms) which will be type 3.
- 12.1.2. Where a public address system has been specified to operate an Audible Alarm for the Fire Alarm system, the Public Address System shall also comply with BS 5839.
- 12.1.3. The public address manufacturer will be responsible for design, manufacture and commissioning of the system, and the Contractor will be responsible for the installation of the system.
- 12.1.4. The public address manufacturer shall be responsible for provision of all details to ensure that the public address system is installed correctly by the Contractor.

12.2. Standards

- 12.2.1. The entire public address system shall be supplied and installed by the Contractor, to ensure that the following listed British Standards are complied with, but not limited to the following:
 - BS 6259: 1982 - Planning and installation of sound systems.
 - BS 7443 : 1991 - Sound systems for emergency purposes
 - BS 5839: 1988 - Fire Detection and Alarm systems for Buildings.

12.3. System Operation

- 12.3.1. Unless otherwise specified within the particular specification the public address system will provide the following operations:
 - Background music
 - Customer/Staff Announcements
 - Emergency Announcements/Alert/Evaluation signals.
- 12.3.2. The systems output shall be via zones as defined within the particular specification.
- 12.3.3. Where safety notification systems are present a signal from the system shall cause the PA system volume to be muted for the notification to be heard.
- 12.3.4. Background music will be provided by a digital source system.
- 12.3.5. Staff announcements will be made by the use of microphones.
- 12.3.6. Alarm signals and messages will be pre-recorded and digitally stored on EPROM. The band width shall be a minimum of 5KHz.
- 12.3.7. Each message module shall be self-monitoring and have fault outputs as well as individual front panel fault indication.

12.4. Control Equipment

- 12.4.1. The public address unit shall be of the 19 inch rack type and made up of modular equipment. Spare capacity of a minimum of 25% shall be allowed for possible future speaker expansion.
- 12.4.2. All inputs including alarms shall be independently set for output level.

12.5. Amplifiers

- 12.5.1. Amplifiers shall be provided in the number and rating required to give the performance specified to satisfy the relevant standards.
- 12.5.2. Each amplifier should allow a spare capacity of 25% for future expansion.

12.6. Loudspeakers

- 12.6.1. Loudspeakers shall be configured in the following types and as defined within the particular specification.
 - Circular mounted within ceiling tiles.
 - Surface Mounted.
 - Surface mounted horn type.
- 12.6.2. All loudspeakers shall have 100 volt line matching transformers with a minimum of three settings/tappings to adjust power levels at each speaker during commissioning equating to 3dB between settings.
- 12.6.3. Ceiling Mounted and surface mounted loud speakers shall have steel enclosure fire rate in accordance with the standards detailed in section 15.2.

12.6.4. The frequency response for ceiling mounted loudspeakers shall be 100-10KHz and sensitivity 1w/1m, 90dB minimum.

12.6.5. The frequency response for horn loudspeakers shall be 275-14KHz and sensitivity 1w/1m, 90dB minimum.

12.7. Microphones

12.7.1. Microphones shall be unidirectional dynamic and desk standing with flexible gooseneck, zone selection and be complete with 2m flexible cable for hard wire connection. The manufacturer shall detail the cable connection to the public address equipment. It shall be connected via fire resistant cable.

12.7.2. The system shall be designed to ensure only one microphone shall have a "busy" indicator.

12.8. Wiring

12.8.1. Where a public address system is used as or part of a fire alarm system, all wiring will be via fire rated twisted pair type cable with an overall covering of red LSF.

12.8.2. All cabling shall be sized to allow for additional 25% speakers.

12.8.3. All speaker cables shall be labelled at both ends denoting the PA Speaker Circuit No. and Zone No.

12.9. Power Supply

12.9.1. The normal mains supply shall be via nominal 240V 50Hz single phase supply.

12.9.2. In the event of mains failure the system shall continue uninterrupted operating from integral standby batteries. The batteries will have sufficient capacity to provide seventy two (72) hours of standby followed by thirty (30) minutes off full alarm load.

12.9.3. In the event of a mains failure where a standby generator shall supply power to the public address system, the public address system will be capable of accepting a generator power supply.

12.9.4. The batteries must be secondary type complete with charging facilities and fault detection.

12.9.5. The charging from a discharged state to a fully charged state shall be a period of no more than twenty four (24) hours.

12.10. Inspection and Testing

12.10.1. The manufacturer will carry out routine tests in accordance with the standards listed in section 2.0.

12.10.2. The complete installation once installed shall be fully tested and inspected to the Engineers satisfaction to prove the following:

- All input and output signals are correct.
- Information given upon fault to any item of equipment is correct.
- Visual alarms can be seen adequately.
- Standby battery duration is achieved.
- All items of equipment carry out their correct function.
- The system achieves required clarity at volume levels throughout the installation.

12.10.3. Following successful commissioning of the system a commission certificate shall be issued in accordance with BS 5839.

13. FIRE DETECTION AND PROTECTION SYSTEMS

13.1. General

- 13.1.1. The Contractor shall test and commission a complete fire alarm system as defined within the particular specification and drawings.
- 13.1.2. The system shall unless defined otherwise within the particular specification be completely from one manufacturer, and be of Open Protocol type.
- 13.1.3. If a closed protocol system is installed all codes to allow full and complete programming and modifications of the system must be provided to allow the client to have the system worked on by any nominated person not just the manufacturer. Failure to provide these will result in the original installing contractor having to make the manufacturer return to site to replace the system with an open protocol system at his cost.
- 13.1.4. Each system shall operate at 24 volts d.c. unless otherwise stated.
- 13.1.5. The equipment and devices shall be produced by the same manufacturer.
- 13.1.6. All components of the system shall be compatible with each other.
- 13.1.7. The manufacturer shall have available written information, technical specifications, and application recommendations guidelines for all proposed equipment.
- 13.1.8. Detectors shall be so designed that removal of one detector indicates a fault but does not render other detectors inoperative. Provision shall be made so that testing of individual detectors can be completed without sounding an alarm.
- 13.1.9. These common bases shall be suitable for fixing to a standard conduit box.
- 13.1.10. Electrical noise, such as high frequency pulses or electromagnetic influences emitted from other equipment shall not lead to false alarms in a detector, manual call point or any other line element.
- 13.1.11. A plan of the premises showing the locations of fire zones and operating instructions for the correct action in the event of a fire or fault indication shall be positioned adjacent to each control and indicating equipment.
- 13.1.12. A log book shall be provided to enable records to be kept of inspections and tests of the system and of incidents, together with their cause and the action taken.

13.2. Standards

- 13.2.1. The complete installation will be manufactured, installed and commissioned, to the following standards and codes of practice, but not limited to the following:
 - BS 5839: Part 1: Fire Detection and alarm systems for building.
 - BS 5839: Part 2: Specification for manual call points.
 - BS 5839: Part 3: Specification for Automatic Release mechanisms for certain fire protection equipment.
 - BS 5839: Part 4: Specification for control and indicating equipment.
 - BS 5839: Part 5: Specification for optical beam smoke detectors.
 - BS 5445: EN54: Part 1 - Components of Automatic Fire Detection System.
 - BS 5445: Part 5 EN54: - Heat sensitive detectors - point detectors containing a static element.
 - BS 5445: Part 7 EN54: - Specification for point type smoke detectors using scattered light transmitted light or ionisation.
 - BS 5445: Part 8 EN54: - Specification for high temperature heat detectors.
 - BS 5445: Part 9 EN54: - Methods of test of sensitivity to fire.
 - BS 7443: Specification for sound systems for emergency purposes.

13.3. Conventional Fire Alarm Systems

- Where specified within the particular specification, the Contractor shall supply and install a conventional fire alarm system.

13.3.1. Main Control Panel

- 13.3.1.1. The main control panel shall be installed flush or surface as indicated upon the drawings and be of the luminous pattern with independent indication for:-
 - Each fire alarm zone.
 - Battery supply.
 - Mains supply.

- Sounder fault.
- Earth fault.

13.3.1.2. Each indication shall have two lamps, the rated voltage of the lamps shall be higher than the system voltage.

13.3.2. The main control panel shall be micro-processor based, and shall be fully monitored.

13.3.3. Facilities shall be available to allow full alarm sectoring, to enable independent sounder operation for each alarm zone, allowing controlled evacuation if necessary.

13.3.4. It shall be possible to switch off detectors at specific times whilst leaving manual call points fully operational.

13.3.5. It shall be possible to generate alternative alert signals by means of a pulsed sound as opposed to continuous tone.

13.3.6. An adjustable timer shall be provided to enable alert signals to be changed to evacuate after a pre-set period, should the alarm not be cancelled.

13.3.7. Auxiliary contacts shall be provided to automatically send and receive signals to remote plant etc., as detailed within the particular specification. In any instance a minimum of one normally open and one normally closed contact shall be provided.

13.3.8. An adjustable timer shall be provided to delay signals to externally manned centres, such as the fire brigade.

13.3.9. It shall be possible to reset detectors and sounders within an individual zone, after alarm initiation, and also allow detectors in individual zones to be reset without operating sounders, when in the maintenance mode.

13.3.10. A master sounder circuit shall be provided allowing a sounder to operate under any alarm condition on the panel.

13.3.11. First fire indication shall be provided to indicate by flashing LED which zone the first fire signal was generated from, to enable location of the origin of the fire.

13.3.12. Repeat facilities shall be provided by means of a multiplexed arrangement allowing the repeat indicators to be operated over two wires.

13.3.13. The power supply and batteries shall be integral and be fully monitored.

13.3.14. The standby power supply shall be provided by means of secondary batteries and floating battery charger. The floating re-chargeable battery shall give a standby period of not less than 72 hours in the monitoring mode followed by a continuous sound signal operating period of not less than one half hour. These durations shall be met at the end of battery design life.

13.3.15. A separate zone designation panel shall be provided adjacent to the control panel with sufficient storage space for system consumables.

13.3.16. The detector and sounder circuits shall be fully monitored for both short-circuit and open circuit, which shall be clearly indicated on the panel.

13.3.17. As such suitable end of line resistors and capacitors shall be installed at the end of each detector and sounder circuit.

13.3.18. The following manual control facilities shall be provided in the fascia of the panel:

- Push Button
- Silence Master Sounder
- Silence Sector Sounders
- Zone reset
- Lamp test
- Cancel fault buzzer

13.3.18.1. Keys

- Key 1 - Activate above controls
- Key 2 - Start sounders

13.4. Analogue Addressable Fire Alarm Systems

13.4.1. Where specified within the particular specification the Contractor shall supply and install a fully addressable analogue fire alarm system.

13.4.2. The system shall be truly analogue with the capability to plot the output from a fire sensor over a time period.

13.4.3. The system shall make a decision as to whether to signal fire or fault alert by comparing this plot against known fire and fault patterns within the control panel's memory. The Memory shall be programmed with one million hours of such information.

- 13.4.4. Once a fire has been detected the system shall indicate by unique address the origin of the fire in descriptive alphanumeric text i.e. "Manager's Office 3rd Floor".
- 13.4.5. Addressability shall be available for all devices including detectors, manual call points, sounders, repeat panels and interface units.

13.5. Main Control Panel

- 13.5.1. The main control panel shall be installed flush or surface as indicated upon the drawings and shall be provided with the following facilities.
- Fire lamp
 - Fault lamp
 - Warning lamp
 - System Healthy lamp
 - LCD Fluorescent display
 - 40 Character Thermal Printer
 - Sound Alarm
 - Silence Alarm
 - Reset Fire
 - Cancel Fault Buzzer
 - Full Qwerty Keyboard
 - Menu Function Keys
 - Alert alarm
 - Evacuation alarm
 - Fire alarm conditions
 - Detector conditions and status
 - Device faulty
 - All "zone" indication
 - Sounders Muted
 - Fire Officers Isolation Switch
 - Zone test, zone isolation and cancel functions.
- 13.5.2. All facilities available within the menus shall be categorised, by means of differing access codes.
- 13.5.3. The menus shall be user friendly by means of prompt guides. Such options shall include:
- Last 100 line events.
 - Last 200 system events.
 - Current fault and wiring logs.
 - Analysis of analogue sensor information.
 - Interrogation of sensor cleanliness.
 - Loop map connections.
 - Enable/disable, detectors, zones, sounders and interface unit channels.
 - Fire plan configuration menus.
 - Outstation label changes.
 - Address allocation.
- 13.5.4. In addition to these listed above the main fire alarm control panel shall be fitted with the following inputs and output contacts as standard.
- no. spare programmable inputs
 - no. spare programmable outputs
 - Automatic dial out of the local fire brigade.
 - Repeater panel (complete with full functions).
- 13.5.5. Unless specified within the particular specification the main fire alarm control panel shall contain 1 no. additional spare loop for future use.
- 13.5.6. Addressing

13.5.6.1. The system shall automatically address every device within the system. All addresses will be "soft" i.e.; without the use of a manual means of setting addresses at the device. Every device within the system shall be microprocessor based to maximise system performance. The system shall have the ability to apply a multi-character alpha-numeric label to each address, ensuring that all information presented by the display is clear and easily understood.

13.5.7. Analogue Operation

13.5.7.1. All sensing devices shall be analogue in performance i.e.; producing variable signal levels for analysis. All data transmission shall be digital form, to prevent corruption during transmission.

13.5.7.2. To ensure performance and compatibility all equipment shall be from one manufacturer only.

13.5.7.3. All system generating software shall be held in a non-volatile memory protected against loss in the event of total system failure by means of a dedicated memory back up battery offering at least 100 hours retention.

13.5.7.4. The use of blown or pre-programmed EPROMS etc. shall not be acceptable for site specific data.

13.5.7.5. Programming of the control panel will initially be carried out by the manufacturer but the system must be such that reprogramming can be carried out by the operators own staff at a later date if required.

13.5.7.6. The programming shall be at 2 levels:

- Limited access menu
- Main access menu

13.5.7.7. The limited access menu shall allow the operators staff to operate the following:

- Printer outputs of all statuses etc.
- Isolate Devices
- Restore Devices
- Isolate Zones
- Restore Zones
- Isolate (Electrically) loops
- Restore (Electrically) loops
- Set Panel Date and Time
- Reset System.

13.5.7.8. The main menu will be accessible to authorised personnel only and will allow the following operations:-

- Configuration of all input/output devices, detectors, etc. to zones, operation of devices, assigning devices to text etc.
- Configuration of auxiliary contacts including additions/deletions.
- Operation of Limited menu including pass words.
- Full test programmes, monitoring current levels etc.

13.5.7.9. The system shall continuously monitor itself. In the event of a failure, a fault warning should be given which should automatically reset after the system has been restarted. The fault will be recorded.

13.5.7.10. The Contractor shall be required to provide full details of all functions of the control panel to the engineer for his approval before manufacturing can commence.

13.5.7.11. In the event of:-

- A faulty section of wiring
- A faulty smoke or heat detector
- A faulty manual call point
- A faulty interface unit

13.5.7.12. The system will automatically disconnect the damaged section/device, and continue to operate the remainder of the system.

13.5.7.13. The system shall have an inherent high immunity from electromagnetic interference by the use of analogue sensing, with built in data checking and digital transmission of data between devices and control panel.

13.5.7.14. The complete Fire alarm systems shall have a backup battery supply in the event of mains failure.

13.5.7.15. The system shall be a floating rechargeable battery, to provide a standby period of not less than 72 hours in the monitoring mode and followed by a 1/2 hour output in the alarm condition.

13.6. Repeater Panel

- 13.6.1. Unless otherwise stated within the particular specification, a repeater panel shall be provided as standard. It shall have the same functions as those listed for the main fire alarm panel.
- 13.6.2. Where a fireman's indicator panel is detailed within the particular specification it shall be located in the position indicated on the design drawings.
- 13.6.3. This repeater panel will indicate via a minimum of two lamps/circuit the following:
 - Systems Healthy (Green)
 - Systems Fault (Orange)
- 13.6.4. All alarm zones are to be indicated via Red LED lamps.
- 13.6.5. Each indication shall have a minimum surface area of 2500mm sq. and shall clearly indicate the zone/system status.
- 13.6.6. A lamp test switch shall also be included to enable all lamps to be tested periodically.
- 13.6.7. Cable entry to the panel shall be from top, bottom or rear.
- 13.6.8. All access to the above panel will be from the front only via a lockable door. Three number keys are to be supplied to the Engineer.
- 13.6.9. Repeat panels for addressable systems shall repeat all of the alpha numeric message on the main LCD display.

13.7. Power Supplies

- 13.7.1. The Contractor shall make full allowance for all such power supplies required for the entire functioning of the complete installation.
- 13.7.2. Power supplies shall be provided in accordance with BS 5839: Part 1, which shall include both normal power supply and stand by power supply.
- 13.7.3. The standby power supply shall be provided by means of secondary batteries and floating battery charger.
- 13.7.4. The floating rechargeable battery shall give a standby period of not less than 72 hours in the monitoring mode followed by a continuous sound signal operating period of not less than one half hour. These durations shall be met at the end of battery design life.

13.8. Detectors, Sounders, Actuators and Ancillary Equipment

- 13.8.1. Manual Call Points
 - 13.8.1.1. Manual call points shall be compatible with fully monitored systems, in conjunction with short circuit monitored zone wiring.
 - 13.8.1.2. An integral LED shall be provided, illuminating when the call point is operating confirming satisfactory operation.
 - 13.8.1.3. The entire unit whether flush or surface shall be coloured Red.
 - 13.8.1.4. The break glass part of the unit shall be plastic covered, for safe simple operation in emergency conditions without the need for a hammer. The glass shall have the words "FIRE - PRESS HARD TO - BREAK GLASS" printed upon it.
 - 13.8.1.5. Operation shall be by means of a contact assembly which utilises a direct mechanical arrangement with only one moving part.
 - 13.8.1.6. Where manual call points are located externally they shall be weather resistant to IP67.
 - 13.8.1.7. Facility shall be provided for "secret" testing by means of suitable keys, for easy testing without breaking the glass.
 - 13.8.1.8. The manual call points shall be suitable for mounting in a pressed steel metal conduit box to BS 1363:1989, for flush installations and a wall mounting box for surface installations
- 13.8.2. Automatic Smoke Detectors
 - 13.8.2.1. Ionisation Type
 - Ionisation types smoke detectors shall automatically detect when an electrical current between two electrodes is broken by small particles of smoke enter the electrode.
 - 13.8.2.2. Optical Type
 - Optical type smoke detectors shall automatically detect when the infra-red source inside the detector head is broken by smoke entering the chamber, thus triggering the alarm.

13.8.2.3. Open Area Smoke Imaging Detection (OSID)

- Smoke detection shall be achieved by means of communication between a wide field of view imaging receiver and a combined Ultraviolet and Infrared emitter. The Emitter shall send coded signals to the receiver at set frequencies as a smoke monitoring strategy. The communication protocol shall be capable of accurately distinguishing between smoke and other potential floating intrusions.

13.8.2.4. Combined Smoke / Heat Detectors

- Multi Sensor type combined detectors shall be installed to provide multiple levels and types of fire detection for smouldering fires with no smoke and flame detection once flames break out.

13.8.2.5. Fixed Temperature Heat Detectors

- Fixed temperature heat detectors shall be set at 57 degrees C.
- An independent indicator lamp shall be attached to each automatic detector to indicate when the unit has been activated. Each unit shall be supplied with an independent common base or addressable base as appropriate incorporating plug-in facilities for the detector heads.

13.8.2.6. Rate of Rise Heat Detectors

- Rate of Rise Heat Detectors shall use a twin bi-metallic element that reacts to a sudden rise in ambient temperature. An override facility shall be provided so that when the rate of rise detector reaches a maximum temperature of 57 degrees C, the device shall operate.

13.8.2.7. Duct Probe Aspiration Pipe Detectors

- These are to be as smoke detectors but are to be mounted on the outside of the air handling duct with sampling tubes projected inside. Where appropriate, remote LED indicators will be provided.
- Each unit shall be supplied with an independent common base or addressable base as appropriate incorporating plug-in facilities for the detector heads.
- The aspiration chamber shall provide its own under pressure (suction) system and shall not rely on the power of the surrounding airflow. By means of suitable piping a solenoid and an automatic scanning device, it shall be possible to monitor a number of pipes by a common chamber/detector arrangement. The functioning of the air valves and piping must be monitored by the control unit. Malfunctions or blockages must result in a fault condition indicated at the aspiration chamber and in the control unit.
- The chamber shall be designed to accommodate a standard smoke detector of either ionization or light scattering (photoelectric) principle.
- The unit shall have a metal housing with provisions for sealed compression cable glands and a built-in test connection plug for an external test unit. The unit shall operate on 24VDC. The unit shall have built-in alarm indicator and fault indication lamps.

13.8.2.8. Visual Alarm Devices (VAD's)

- VAD's shall be used as a supplementary means of alerting building occupants in the event of a fire.
- VAD's shall primarily be installed in areas where people with impaired hearing are likely to occupy the space, areas where an occupant is likely to be alone, toilet facilities, fire alarm systems with incorporated gaseous extinguishers and areas where hearing protection is mandatory, advisory or discretionary requirement.
- The device shall provide an illuminance of no less than 0.4 lux from the surface perpendicular to the light ray being emitted from the VAD and have a flash frequency spectrum of 0.5Hz to 2Hz.
- Adjustment to all VAD's shall only be possible via the breaking of the manufacturers seal or advised/used by the manufacturer.
- Type B VAD shall be rated to IP33C in line with (BS EN 54-3).

13.8.2.9. Smoke Beam Detector

- Where smoke beam detectors are detailed to provide volumetric detection, they shall consist of a transmitter unit which projects an infra-red beam into a receiver unit.
- The alarm shall be initiated when smoke impedes the beam.

- The arrangements shall be in three separate types, transmitter, receiver and control unit mounted in easily accessible locations.
- The infra-red beam shall be modulated to avoid false alarms which might be caused by other infra-red sources such as sunlight or heating appliances.
- A pre-set delay shall be provided between the beam being broken and the alarm being initiated, to prevent false alarms.
- The control unit shall be addressable where appropriate.

13.8.3. An independent indicator lamp shall be attached to each automatic detector to indicate when the unit has been activated. Each unit shall be supplied with an independent common base or addressable base as appropriate incorporating plug-in facilities for the detector heads.

13.8.4. Relays

- 13.8.4.1. Remote auxiliary relays which may be detailed within the particular specification for the switching of heavy loads on the fire alarm system, such as door release units, plant shutdown, smoke ventilators etc. shall be housed within suitable enclosures.
- 13.8.4.2. These enclosures shall be low profile where mini-type relays are used for light loads, or deep enclosure where a mixture of mini or octal based relays/timers are housed for heavy load applications.
- 13.8.4.3. The enclosure shall be weather resistant to IP67, and manufactured from a polycarbonate construction.
- 13.8.4.4. The enclosure shall be provided with pre-pressed knockouts on sides and base, enabling the enclosure to be mounted in any position.
- 13.8.4.5. A DIN rail mounting bar shall be installed to allow the relays and timers to be fitted without a chassis for quick and easy installation and maintenance.
- 13.8.4.6. All relays and timers shall be provided with DIN rail mounting bases.
- 13.8.4.7. Where a high quantity of relays and timers are necessary, and it may be more economical to centralise the control, a high capacity panel type enclosure may be utilised, the detail of which shall be provided to the engineer for approval.

13.8.5. Automatic Door Holders

- 13.8.5.1. Automatic door holders shall be utilised, where detailed within the particular specification, to operate with freely swinging doors, fitted with efficient door closers.
- 13.8.5.2. The door holders shall be magnetic. The electromagnet shall be sufficient to hold open the door in normal conditions.
- 13.8.5.3. This shall be achieved by mounting the door plate on the door surface, positioned such that, it is held wholly and squarely by the respective magnetic holder.
- 13.8.5.4. The door holder will operate at 230v a.c. which shall be connected via a suitably rated relay, which in the event of a fire signal will interrupt the supply automatically closing the door.
- 13.8.5.5. The mains supply shall be independent, provided by the Contractor, which shall cause the door holders to release on loss of normal supply.
- 13.8.5.6. An integral switch shall be provided to allow manual release of the door by de-energising the electro magnet.
- 13.8.5.7. The units shall be either surface or recess mounted as detailed within the particular specification. All elements shall be supplied and fixed by the Contractor.
- 13.8.5.8. Full details will be submitted with the tender return.

13.8.6. Interface Devices

- 13.8.6.1. Interface devices are to be utilised within addressable fire alarm systems to enable connection of conventional equipment into the system.
- 13.8.6.2. These shall be programmable relays connected into the address loop.
- 13.8.6.3. Their function is to:
 - Send a signal to an item of plant from the Fire Alarm Panel.
 - Send a signal from an item of plant to the Fire Alarm Panel.
- 13.8.6.4. Each interface unit shall be supplied from a 24v supply, which will be derived from a number of central sources.
- 13.8.6.5. The fire alarm manufacturer will be responsible for supply of these 24 volt supply units which will be provided with a 72 hour back up battery supply.

- 13.8.6.6. The 24v independent supply is to be fault monitored by the control system via an interface unit. In the event of failure, the main control panel is to indicate a fault on the system.

13.8.7. Short Circuit Isolator Units

- 13.8.7.1. Short circuit isolators shall be installed at strategic points of the address loop in addressable systems. This shall be as detailed within the particular specification but shall normally be located between a maximum of twenty devices, with a maximum of 12 isolators per loop.
- 13.8.7.2. Should a short circuit occur within the address loop, the isolators will operate automatically, and isolate the faulty section of cable. The remainder of the system shall continue to function normally.
- 13.8.7.3. The devices will also send a fault signal to the main control panel, indicating which device has operated in order that the fault can be rectified.

13.8.8. Sounders

- 13.8.8.1. Alarm bells shall be 150mm or 200mm under dome type as specified and be suitable for operating on 24 volt dc.
- 13.8.8.2. Electronic sounders shall have sound characteristics complying with the frequency requirements of BS 5839: Part 1. A volume control facility shall be incorporated inside the unit to enable the sound output to be set to a wide range of locations. Additionally sound mode selection shall make available three sound options namely.
- Intermittent Tone
 - Warble Tone
 - Continuous Tone
- 13.8.8.3. Volume control shall be adjustable from zero to maximum sound output which shall be 100 d(B)A at one metre in the continuous tone mode.
- 13.8.8.4. A special tool shall be required to separate the horn from the base to prevent idle tampering.
- 13.8.8.5. Sounder bases shall be addressable where appropriate.
- 13.8.8.6. Where sirens are detailed within the particular specification they shall be mounted on a detachable base box, and be of a metal construction. The base box shall contain the wiring terminals.
- 13.8.8.7. The siren shall be fixed such that the rotor does not face upwards.
- 13.8.8.8. Sirens shall produce a minimum sound output of 110 dB(A) at three metres.

13.8.9. Xenon Beacons

- 13.8.9.1. Within certain noisy areas where sounders maybe ineffective, high intensity visual warning signals will be required by provision of Red Xenon flashing beacons.
- 13.8.9.2. Such beacons shall flash at approximately 1 Hz, with low current consumption.
- 13.8.9.3. They shall be manufactured from a polycarbonate material to provide a high degree of protection against vandalism or accidental damage.
- 13.8.9.4. The unit shall be weather resistant to IP54 and capable of operating within temperature ranges from - 40°C to +60°C.
- 13.8.9.5. Reverse polarity protection shall be provided preventing damage if incorrect voltage polarity is applied, enabling the unit to be connected to monitored sounder circuits.
- 13.8.9.6. The bases shall be addressable where appropriate.
- 13.8.9.7. Since January 1st 2014 all beacons that are used as visual alarm devices (VAD's) must comply with EN54-23 and CoP0001. EN54-23 Beacons are to be provided to all shower rooms, accessible w/c's and specified disabled service provision / user areas, with the remainder of beacons to be indicators. Where devices are to be classed as VAD's, they must be conventionally wired type fed from the fire alarm panels. These are to provide 0.4lux on adjacent walls/surfaces in alarm to the locations where VAD's are required.

13.8.10. Ancillaries

- 13.8.10.1. Where detailed within the particular specification the following ancillary equipment maybe required.
- 13.8.10.2. Flame detection.
- Hazardous area equipment.
 - Auxiliary power supplies.
 - Mimic Displays

- Fireman control panels.
- Digital communication equipment.
- Interface equipment.

13.8.10.3. The specific requirements for these items will be detailed within the particular specification.

13.9. Wiring

- 13.9.1. The Contractor shall install the fire system using light/heavy duty, mineral insulated copper red LSF sheathed cables, or as described elsewhere within this specification.
- 13.9.2. The sub-contractor shall pay particular attention to the way in which the fire alarm zones have been designed. Any deviation from the design drawing shall be subject to written approval from the Engineer prior to installation.
- 13.9.3. Cables shall be looped between equipment, junction boxes shall be kept to a minimum. Where junction boxes are utilised they shall be identified by a label inscribed "FIRE ALARM".
- 13.9.4. Cabling shall be concealed within riser ducts, trunking, ceiling voids, floor voids etc. with the exception of plant areas where the cabling shall be exposed.
- 13.9.5. Conductor sizes shall be as detailed elsewhere within this specification and upon the drawings. However, the minimum conductor sizes shall be as follows.
 - Automatic detector and manual break glass circuits - 1.5mm².
 - Audible alarm circuits - 2.5mm².

13.10. Inspection, Testing and Commissioning

- 13.10.1. The whole of the fire alarm system installation shall be inspected, tested and commissioned in accordance with BS 5839: Part 1 and as further described.
- 13.10.2. The Contractor shall employ the fire alarm equipment manufacturer to commission the entire system.
- 13.10.3. Commissioning shall be carried out in accordance with BS 5839 : part 1, which shall include:-
 - An audibility test of the alarm devices. Audibility level readings shall be taken in each room using an instrument complying with BS 5969, type 2 with slow response and a weighting. Any sound pressure levels found to be lower than that required by BS 5839: Part 1 shall be reported, in writing, to the Engineer.
 - All trigger devices i.e.: manual call points heat detectors and smoke detectors shall be tested for correct operation.
 - A mains failure test shall be carried out to verify the standby battery system complies with the requirements of BS 5839.
- 13.10.4. Prior to commissioning the Contractor shall provide a certificate of installation and commissioning of the system (see Appendix B and C of BS 5839: Part 1) to the Engineer. It should be noted that a Practical Completion Certificate will not be issued until this installation and commissioning certificate has been received, and the installation and commissioning certificate will not be accepted unless it is accompanied with the Record Drawings and User Manuals and the system Log Book, (see Appendix D of BS 5839 : Part 1).
- 13.10.5. The fire alarm (upon full or phased completion) shall be commissioned and / or tested to achieve the following:
 - Verification of cable continuity and impedance within manufacturers limits
 - Labelling and verification of all loop devices
 - General operation of devices
 - Cause and effect operations
 - Cause and effect verification
 - Functionality of interfaces
 - Operation of dial out
 - Returns to normal status upon full reset
 - Demonstration of system
- 13.10.6. The testing of the system shall be undertaken by a competent person who is familiar with, and trained for, the commissioning of the type and make of system installed.

13.10.7. The testing and commissioning must be undertaken in line with the manufacturer's requirements and guidelines.

13.10.8. Upon completion of fire alarm testing and commissioning the following must be provided:

- Audibility to be proven and recorded on as built drawings
- Battery backup status / provision
- Proof of operation to the client
- Certification
- Log books
- Provision of as built drawing
- Provision of zone charts
- Emergency operating procedures
-

14. EARTHING AND BONDING

14.1. General

14.1.1. All materials used in the earthing network shall be of High Conductivity annealed copper of type, size and with protective covering manufactured to the appropriate British Standards.

14.2. Standards

14.2.1. All earth and bonding shall be carried out to ensure compliance with British Standards and all relevant requirements but not limited to these listed below:

- Electricity at work Regulations 1989.
- BS 7671 Latest Edition Wiring Regulations. Requirements for Electrical Installations and all amendments.
- The Electricity Supply Regulations 1988 (as amended)

14.3. Main Earth Network

14.3.1. Where defined within the particular specification the main earth network shall consist of 18mm diameter copper coated, steel core earth rods driven vertically into the ground.

14.3.2. The rods shall have external threads for connecting with a proprietary joining sleeve. These rods shall be connected to each other and to any main earth test point using clamps-strand connections fixed to the head of each rod and earth cable. Earth cables shall be buried 750mm below ground level and rise vertically alongside each rod to enter the clamp. Buried cables shall be covered along their route with plastic cable route marker tape 300mm below ground level.

14.3.3. The resistance to earth of the electrode system shall not be greater than 0.5 ohms. Site tests are to be carried out when the rods are connected to ensure that the electrode system meets this requirement. Any deviation from the above shall be reported to the Engineer.

14.3.4. All earth rods will be installed via a concrete inspection pit. Such pits shall be made from purpose made concrete housing inscribed "EARTH ROD", fitted with removable inspection cover from external locations. For internal locations a puddle flange, pit frame, end cover and duct from pit to adjacent wall.

14.3.5. The electrical contractor shall provide full builders work details for pit construction.

14.3.6. All connections shall be labelled "Safety electrical earth – do not removed"

14.4. Bonding of Incoming Services

14.4.1. The consumers' earth terminal of the building shall be bonded to the metalwork of the incoming gas and water services and any other incoming services or rising mains such as ducting hot and cold water services or fire main services.

14.4.2. If there is more than one entry of any of the above services into the building then each entry must be bonded.

14.4.3. The bonding connection shall be made as near as practicable to the point of entry except in the case of the gas service where the connection shall be in the consumers side of the meter and must in all cases be in such a position that it will be easily accessible for inspection.

14.4.4. The bonding cable shall be LSF sheathed insulated cable coloured green/yellow enclosed in heavy gauge steel conduit which is to be flushed into the wall where possible. This cable must be of continuous length

and a minimum cross-sectional area of 6mm². The actual size shall be in accordance with the relevant BS 7671 tables.

14.5. Main Earth Bars

- 14.5.1. Where main earth bars are specified within the particular specification, they shall comprise of a suitably sized copper bar, equipped with clamps to accommodate the incoming and outgoing cables and tapes. The earth bar shall be affixed to the building structure by means of adequately sized phosphor bronze bolts and provided with insulated stand-off brackets.
- 14.5.2. The earth bar shall be identified by a suitable label marked **Main Earth bar** and all connections labelled "Safety electrical earth – do not remove"
- 14.5.3. All exposed conductive parts of generators, transformers and main switchgear shall be connected to the main earth bar in accordance with the following table:

• 1 second current rating	Minimum cross section of copper
• of switchgear (KA)	earth conductor (sq. mm)
• not exceeding 22	95
• not exceeding 30	150
• not exceeding 44	300

14.6. Bonding of Cables

- 14.6.1. All metal pipes or conduits in which the cables have been installed shall be connected to the earthing system. The joints, metal sheath and armour, if any, of the cables shall be connected to the main earthing system in an approved manner.
- 14.6.2. The Contractor shall ensure that cables are earthed in accordance with the following:-
 - 14.6.2.1. The sheath and armour of multicore paper-insulated cables and the armour of PVC insulated armoured cables shall be connected at each end to the earth bar or terminal of the associated switch or fusegear.
 - 14.6.2.2. The sheath of main or sub-main multicore MIC cables shall be connected at each end to the earth bar or terminal of the associated switch or fusegear.
 - 14.6.2.3. A brass or copper clip shall be fitted to the sheath immediately before the gland.
 - 14.6.2.4. The sheaths of single core MIC cables used as main or sub-main feeders shall be bonded together and connected to the earth bar or terminal of the associates switch or fuse-gear, at each end. A brass or copper clip shall be fitted to the sheath immediately before the gland.

14.7. Main Equipotential Bonding Conductors

- 14.7.1. The Contractor shall install main equipotential bonding conductors to the following items, unless otherwise defined within the particular specification.
 - All incoming gas main systems
 - All incoming water main systems
 - All incoming sprinkler systems
 - Other metal service pipes and ducting
 - All structural steelwork
 - All incoming metal sheathed telephone cables – subject to the service providers agreement
 - The lighting protection system
 - Clean Earth
 - Supplementary earthing
 - All the above main equipotential bonding shall be carried out with single core LSF insulated conductors of the size shown on the design drawings or detailed in BS 7671.
- 14.7.2. An engraved type label Red/White/Red with minimum character height of 10mm. engraved "**SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE**". This label is to be screwed to the wall or other suitable fixed structure in a prominent place.

14.8. Supplementary Equipotential Bonding

- 14.8.1. The Contractor shall provide a supplementary equipotential bonding system to all necessary exposed and extraneous conductive parts of the building, unless otherwise specified within the particular specification.

- 14.8.2. All cables shall be terminated directly into designated earth terminals or by propriety earth clamps. Such clamps shall comply with BS 9511, complete with a permanent label indelibly marked with the words "SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE".
- 14.8.3. Generally items of equipment to be bonded shall have installed next to an empty conduit, flush or surface, terminating into a standard BESA box. The item being bonded shall be terminated to this point.
- 14.8.4. Where flexible conduit is used for final connections, earthing of equipment shall be carried out by a minimum of 4mm² 7/0.85 green and yellow LSF insulated copper protective conductor run through the flexible conduit and connected by crimped lugs to the earth terminal of the equipment being earthed and the earth terminal of the conduit should be crimped into a common lug.
- 14.8.5. The sizes of the supplementary bonding conductors shall be not less than 4mm² and shall comply with the requirements of BS 7671.
- 14.8.6. All electrical accessories mounted on metal boxes will have protective conductor installed between the accessories box and its earthing terminal.
- 14.8.7. At all supplementary equipotential bonding terminations, the Contractor shall install labelling as described below:-
- 14.8.8. A durable permanent label with characters of minimum height of 4.75mm. With the words "**SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE**". These labels are to be fitted adjacent to earthing terminals.
- 14.8.9. The extent of the works requiring bonding shall not be limited to those shown on the design drawings or listed within this section of the specification.

14.9. Telephones

- 14.9.1. The incoming telephone system shall be connected to the main earth bar via a 6mm² LSF insulated copper protective conductor served in a separate 25mm², metal conduit throughout its entire length. Any metallic sheath or armour of the incoming telephone cable shall be main bonded where it enters the building subject to the system provider's agreement.

14.10. Lightning Protection Systems

- 14.10.1. The lightning protection system shall be connected to the main earth bar via 25mm x 6mm high conductivity copper tape (minimum size).
- 14.10.2. It shall be the Contractors responsibility to connect the lightning protection system to the main earth bar.

14.11. Testing and Commissioning

- 14.11.1. The Contractor shall give the Engineer fourteen days prior notification before commencing with the testing and commissioning of the earthing system.
- 14.11.2. The Contractor shall prove the following by means of inspection in conjunction with the engineers, but not limited to the following, the results of which shall be issued in a tabulated format by the Contractor.
 - Resistance and continuity of protective conductors.
 - Type of cable and type complies with specification.
 - Cross sectional area of earthing conductors.
 - Confirmation of identification of protective conductors is correct.
 - That all connections have been correctly made.
 - That the installation is fully labelled.
 - Any readings found to be in excess of the design shall be reported to the Engineer.

15. LIGHTNING PROTECTION

15.1. General

- 15.1.1. The lightning protection system shall be installed as indicated on the drawings by the Contractor or his representative, who shall be experienced in this type of installation.
- 15.1.2. The installer shall be a member of the National Federation of Master Steeplejacks and Lightning Conductor Engineers and the name of the proposed specialist shall be submitted with all tender submissions.
- 15.1.3. The Contractor shall seek written approval from the Engineer and Architect prior to any drilling of waterproof building fabric.
- 15.1.4. The installation shall be so arranged to prevent contact between dissimilar metals in the lightning protection system and the building fabric giving rise to corrosion through electrolytic or chemical action.

- 15.1.5. Aluminium tape shall not be used below building damp proof membrane level nor between the test clamp and the earth electrode.

15.2. Standards

- 15.2.1. The lightning protection system shall comply with:-
- BS EN 62305:2006 Protection of structures against lightning
 - BS EN 755:1996 Wrought aluminium and aluminium alloys.
 - BS EN 1652:1998 Rolled copper & copper alloys: sheet, strip & foil.

15.3. Materials

- 15.3.1. Unless defined within the specification copper tape shall be used throughout with a PVC covering, colour to be agreed with the Architect prior to installation.
- 15.3.2. Tape shall be either high conductivity annealed copper to BS EN 1652:1998 or aluminium to BS EN 755:1996. Copper and aluminium shall not be mixed in any one system. The minimum size shall be 25 x 3mm. Fixings shall be purpose made. Joints shall be either brazed, fusion welded or made by means of purpose made clamps. Bonds to exposed metalwork shall be in the same material as that part of the system to which they are connected.
- 15.3.3. Saddles and holdfasts shall be either gun-metal, bronze or high tensile brass for copper tape. Aluminium, alloy or stainless steel for aluminium tape.
- 15.3.4. Down conductor clips shall be outdoor grade polycarbonate or polypropylene, coloured to match the PVC sheath. Screws, bolts or nuts shall be stainless steel.
- 15.3.5. Earth electrodes shall be either copper bonded to steel rod, of minimum diameter 18mm. Joints between rods shall be treated to inhibit corrosion.

15.4. Earth Terminations

- 15.4.1. Earth terminations shall be provided in the locations shown bonded to the reinforcement of the pad foundations installed in pre-cast concrete inspection pits, as indicated on the Contractors drawing. The maximum impedance of the total system to earth shall not exceed 10 Ohms and the maximum impedance of each termination shall not exceed ten times the total number of terminations.
- 15.4.2. The Contractor or his specialist Contractor must take due account of readings for impedance achieved by the test earth rod, shall test after casting of pads and in the event of the test figure exceeding ten times the total number of terminations then additional terminations shall be agreed with the Engineer.

15.5. Air Terminations

- 15.5.1. At roof level all external metal work is to be connected to the lightning protection system.
- 15.5.2. This shall include but not be limited to the building roof and gables, plant rooms, lift motor room, tank room, light wells and the like. Exposed metallic items such as metallic cladding, roof decking, chimneys, vent pipes, cowlings, plant, frames, handrails, walkways, aerials, staircases and the like shall be bonded to the nearest air termination or down conductor.
- 15.5.3. The air termination network shall consist of 25 x 3mm high conductivity copper tape with rounded edges fixed to the surface of the roof areas by proprietary clamps.

15.6. Down Conductors

- 15.6.1. Down conductors shall be provided around the building perimeter at spacings in accordance with the British Standard and in agreement with the Architect. Down conductors shall consist of PVC sheathed solid copper conductors installed within the columns of the building.
- 15.6.2. Where a down conductor is run internally, it shall be enclosed in an insulating, non-combustible duct, sealed as appropriate as structural fire and water barriers.
- 15.6.3. As a minimum, each down conductor shall be fitted to a 16mm, 3m long copper clad steel cored earth electrode contained within a concrete earth inspection pit.
- 15.6.4. Each down conductor shall be provided with a test clamp.
- 15.6.5. Test clamps shall generally be located on the outside of the building structure 300mm above the finished ground level. Where the fabric of the building is glass, the test clamp shall be located within a dummy length of the Air Distribution Duct, adjacent to the column.

- 15.6.6. The installation shall also be connected to the main earth bar of the building, via a test clamp. The cabling will be by others. The lightning protection manufacturer is responsible for provision of a suitable connection at ground floor level, next to the L.V switch room.

15.7. Tape Joints (General)

- 15.7.1. Compression joints between similar metals shall conform to BS 4579. Contact surfaces shall be thoroughly cleaned and treated with the appropriate corrosion inhibitor. A minimum overlap shall be allowed of 20mm on tee joints and 75mm on lap joints.
- 15.7.2. Bi-metallic joints shall be made by means of friction-welded bi-metal connectors and shall not be used within 300mm of a test clamp.
- Joints prone to moisture attack, such as to the reinforcement in structural concrete, below building damp proof membrane and the like shall be sealed to prevent the ingress of such moisture.

15.8. Cast in Earth Pits

- 15.8.1. The Contractor and/or his representative shall install concrete inspection earth pits in the locations indicated on the drawings.

15.9. Early Streamer Emissions (ESE) Lightning Protection

- 15.9.1. The ESE air terminal shall be installed in a way that ensures it is the highest point of vertical contact for the building it serves to protect.
- 15.9.2. Suitable guard tubes shall protect the down conductor of the ESE system vertically by at least 2m from the conductors penetration at ground level.
- 15.9.3. A down conductor with a CSA of at least 50mm², flat conductor/tape with a tinned plated exterior shall be a minimum requirement unless specifically stated otherwise within the accompanying documents.
- 15.9.4. The current impulse caused by lightning shall be monitored by the use of a lightning event counter installed over the protective guard tube of the down conductor in accordance with BS EN IEC 62561-6. The data from the event counter shall be transferable via a SD/USB device to other PC devices.
- 15.9.5. The air terminal of the ESE system shall be earthed using 2No. down conductors routed on two different external walls of the building.
- 15.9.6. The contractor shall ensure that the installation of all down conductors have a straight path to the earth terminal and effort shall be made to prevent excessive and acute bends occurring throughout the conductive path.
- 15.9.7. Conductors shall not be routed across power cables or gas pipes. Down conductors shall maintain a distance of at least 1 metre between power cables and 5 metres between gas pipes.

15.10. Earth Electrodes

- 15.10.1. The earth electrodes shall be driven into the ground (due consideration shall be given to the location of underground services e.g. drainage pipes, electricity cables etc. before the rods are located). However the rods shall be located as near as practicable to the down conductors. An allowance of two 1.2 metre rods at each earth electrode point shall be made.
- 15.10.2. Electrical resistance measurements shall be taken during the driving of the rods to indicate a condition under which it is unlikely that any further reduction in resistance will be obtained by additional lengths of rod being installed. Under these conditions the Engineers advice should be sought.
- 15.10.3. Each earth electrode should have a resistance to produce a resultant resistance of the whole earth termination network of less than 10 ohms.
- 15.10.4. It is the lightning protection system installer's responsibility to ensure that the completed scheme conforms to BS EN 62305:2006 in as aspects.

15.11. Inspection, Testing and Commissioning

- 15.11.1. Before the system is deemed acceptable the complete system is to be inspected and tested.

15.11.1.1. Inspection

- The lightning protection system shall be visually inspected during the installation and after completion by a competent person to verify that the installation meets the required standards.
- All mechanical connections are to be checked including conductor bonds, joints and earth electrodes.

15.11.1.2. Testing

- Upon completion, the entire system shall be tested in accordance with Section Five of BS EN 62305:2006 and the results recorded on the appropriate certificates.
- The following measurements should be made and the results recorded in a lightning protection system logbook to be provided by the supplier.
- The resistance to earth of the earth termination network and of each electrode.
- The results of a visual check of all conductors, bonds and joints or their measured electrical continuity.

15.11.1.3. The recommended method of testing is given in CP 1013. If the resistance to earth of a lightning protection system exceeds 10 ohms the value shall be reduced.

15.11.1.4. The completed system will be inspected, tested and commissioned in the presence of the engineer.

15.11.1.5. The Contractor shall notify the engineer three weeks in advance such as that site witnessing of the test can be achieved.

15.11.2. Record Drawings

- Record drawings shall be produced which shall detail the positions of all cables, electrodes, terminations and test clamps.
- Setting-out dimensions, lengths and impedances of all earth electrodes shall also be shown on these drawings.

16. GENERAL SYSTEMS

16.1. General

- 16.1.1. Unless stated otherwise within the particular specification the Contractor shall install the following listed systems.
- 16.1.2. The Contractor shall be responsible for liaising with the various specialist suppliers to ensure that the system is installed to the highest standards.

16.2. Telephone Systems

- 16.2.1. The Contractor shall supply and install all wire, cables, cable support systems, cable enclosures and accessories to form a complete telephone installation as described within the particular specification.
- 16.2.2. The telephone system shall be completely separate from all other electrical services, in its own unique wireway.

16.3. Security System

- 16.3.1. The Contractor shall supply and install all wire, cables, cable support systems, cable enclosures and any accessories to form a complete security system installation as disciplined within the particular specification.
- 16.3.2. The Contractor shall supply and install any electrical power requirements and associated equipment in order to complete the security system.
- 16.3.3. Where appropriate the Contractor shall employ a specialist contractor to design, install, test and commission the system.
- 16.3.4. The security system shall be completely separate from all other electrical installation, in its own unique wireway.

16.4. Data Cable System

- 16.4.1. The Contractor shall all cables, wires, cable supports systems (as described elsewhere within the specification) and accessories to form a complete system to the satisfaction of the particular specification.
- 16.4.2. Throughout the installation, data cables shall be installed onto dedicated containment basket. Where data cables run with LV cabling, the data cables shall be a minimum of 50 mm away, and shall run at 90° if crossing any LV cabling.
- 16.4.3. Under the Construction Product Regulations (CPR) for the reaction to fire performance of cables, the contractor shall supply, install test and commission a sub main cable installation utilising low fire hazard cables with a Euro Class category rating in accordance with EN50399 & EN50575.
- 16.4.4. Ratings shall generally be as follows:

Euroclass Level	Description	Example Environment
B2ca	Very high fire protection, self-extinguishing	Hospital Wards, children's nurseries, above fire exits, designated escape routes in public buildings, airports, train stations, underground stations.
Cca	High fire protection, self-extinguishing	Hospitals, commercial buildings, leisure facilities, hotels, schools, administration and office buildings.

- 16.4.5. In order to support compliance with the Construction Product Regulations (CPR) a harmonised colour coding system has been established to differentiate between the Euro Class categories of cable installations the Cca cable installation shall be installed with a green sheath cable and B2ca shall be orange.
- 16.4.6. The contractor shall include to provide a copy of the cable manufacturers Declaration of Performance (DOP) certificate on completion of the structured cable installation to ensure compliance, this shall be included in both paper and electronic format.
- 16.4.7. All wiring other than in plant areas shall be concealed within floor voids, ceiling voids, ducts etc., or within wall chases. Specific areas, and only if indicated on the drawings may be served via surface mounted. Surface wiring within plant areas shall be run within galvanised conduit, trunking or cable tray.
- 16.4.8. The data cabinet shall be connected with a 'clean earth' from local distribution board.
- 16.4.9. Cabinet shall be supplied and installed by the contractor.
- 16.4.10. At least 2 x Rear vertical cable management tray, for backbone and/or horizontal wiring, and a further two for client patch management with front side mounted brush strips/letter boxes.
- 16.4.11. The data cable system shall be a completely separate system from all other electrical services, installed in its own unique wireway.
- 16.4.12. The Cat 5e/Cat 6 installation shall be tested using a recognised tester and all test results to be provided and included in the building manuals.
- 16.4.13. All final connections shall be terminated into RJ45 sockets in locations shown on drawing. The data cables shall be terminated to the patching panels, one number cable per way on the racks. Patching numbering protocol shall be as per Client's requirements.
- 16.4.14. The labelling of the data cabling is specific for the Client and their system of labelling is to be adopted.

17. ELECTRICAL SERVICES ASSOCIATED WITH MECHANICAL SERVICES

17.1. General

- 17.1.1. Unless otherwise specified within the particular specification the Contractor shall install all wiring associated with the heating, ventilation, air conditioning and water services shown on the drawings and or listed within the particular specification.
- 17.1.2. Water services shall include hot and cold water distribution, fire protection services and any other water services.

17.2. Wiring Systems

- 17.2.1. All mechanical plant shall be wired in a manner described within the appropriate section of this specification, the type and sizes of cables, wires, cable enclosures, equipment plant and accessories shall be as described within the particular specification.

17.3. Installation

- 17.3.1. All mechanical plant and equipment shall be wired in accordance with the appropriate clauses in this specification to provide a complete working installation.
- 17.3.2. The Mechanical Services Contractor will supply and install all mechanical plant and associated equipment for the building as indicated on the drawings.
- 17.3.3. It shall be the Contractors responsibility to check the precise requirements of each item of plant before carrying out the installation.
- 17.3.4. Any deviation from the schedule enclosed within the particular specification, must be reported to the Engineer before installation commences in order that the cost implications of any deviations may be evaluated before installation commences.
- 17.3.5. Adjacent to each item of mechanical plant the Contractor shall supply, fix and connect a suitable isolator as indicated in the Schedule.

- 17.3.6. Where connections are made to motors and thermostats mounted on pipework or ducting etc., these shall be made with cables in LSF sheathed flexible conduit from a conduit through box.
- 17.3.7. Each motor shall be provided with effective means of isolation which shall be located adjacent to the motor, and which, in the case of a DOL motor shall be a triple-pole or single pole and switched neutral (as appropriate) switch disconnector.
- 17.3.8. Motors fed from the Mechanical Services control panel shall have a remote switch disconnector, mounted adjacent to it.
- 17.3.9. All wiring shall be carried out in LSF insulated cable contained in conduit or trunking, unless otherwise stated within the particular specification.
- 17.3.10. Connections to the various items of plant shall be made with cables in galvanised conduit, which shall generally be installed at high level and then drop vertically to suitable positions adjacent to each item of equipment to be served.
- 17.3.11. When conduits span between the structure and items of plant or plant bases, they shall be effectively supported and stayed by means of galvanised Unistrut or Leprack channel and accessories.

17.4. Final Connections to Motors

- 17.4.1. Final connections to motors with ratings up to and including 3.0 kW shall be either stranded LSF cables in flexible conduit or multi-core metal braided cable LSF oversheath, as appropriate, to suit the motor cable termination arrangement.
- 17.4.2. Connections to motors with ratings above 3.0 kW shall be by means of stranded LSF cables enclosed in flexible conduit, or armoured cable.
- 17.4.3. Unless otherwise specified, final connections to motors in cables up to and including 6mm² shall be single core stranded LSF cables or multi-core metal braided/LSF cables. Final connections over 6mm² shall be XLPE/SWA/LSF cable.
- 17.4.4. Where final connection to motors is in flexible conduit a stranded copper green/yellow LSF earth connection shall be made from a brass earth stud in the conduit box to the motor earth terminal. The cable shall be run inside the flexible conduit and shall be of minimum size 2.5mm².
- 17.4.5. Motors wired in XLPE/SWA/LSF cable shall terminate directly into the motor terminal box.
- 17.4.6. Terminations shall be made with compression lugs.
- 17.4.7. Each motor terminal box shall be provided with an earth terminal and lug.

17.5. Final Connections to Controls

- 17.5.1. Final connections to motorised valves, thermostats, motorised dampers, etc., comprising field mounted items in plant, pipework and ductwork forming part of the Mechanical Services electrical control equipment shall terminate in flexible connections.
- 17.5.2. The flexible connection shall be by multi-core XLPE insulated metal braided LSF bedded served cable.
- 17.5.3. The cable shall be complete with stuffing glands at each end.
- 17.5.4. The cable shall terminate at the equipment terminals at one end and in circular base box or an adaptable conduit box adjacent to the equipment. The flexible cable conductors shall connect to the circuit conductors via terminals mounted within the conduit box.

17.6. Water Heaters

- 17.6.1. The final connection from the switch or fused connection unit shall be made directly to the terminals of the heater.
- 17.6.2. 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.
- 17.6.3. The connection shall enter through the back of the heater where possible.

17.7. Motor Controls

- 17.7.1. Motor control gear enclosures shall contain all contactors, relays, timers and protective devices necessary to operate each motor in accordance with the particular specification.
- 17.7.2. Motors to be controlled and the type of starter shall be as shown on the drawings.
- 17.7.3. The following facilities shall be fitted to the enclosure:-
 - Isolator, interlocked with the door, capable of breaking the motor stalled current
 - Start push-button, coloured green and shrouded
 - Stop push-button, coloured red and shrouded

- Duty selector switch
 - Ammeter for motors of 5kW or more
 - Motor running lamp with green coloured lens
- 17.7.4. Where shown or where controls are not readily accessible from the motor, emergency stop-buttons of the mechanical latch type shall be provided local to the motor, wired to the starter.
- 17.7.5. All motor control gear shall be of uniform manufacture, and shall comply with BS EN 60947-4-1: 2019.
- 17.7.6. HRC fuses to BS 88 type Q1 category AC46 or fast acting Thyristor fuses shall be provided for short circuit protection with separate control circuit fusing when the main fuses exceed 15 Amps.
- 17.7.7. Manually reset thermal overloads with phase failure protection shall be provided. A voltage free normally open contact shall be provided complete with terminals for remote indication that the overload device has operated. Overload heaters shall be replaceable.
- 17.7.8. Electronic Soft Start Units
- 17.7.8.1. Where specified, electronic soft start units shall be installed between the main contactors and three phase ac motors which shall:-
- Apply voltage to the motor at a present lower value and then increase steplessly at a variable rate to full mains voltage;
 - use energy optimising circuitry with digital, open loop control based on the Fairford 3MC control chip or other approved;
 - Use a 6-way Thyristor controller with fast acting fuse protection;
 - Release the main contactor in the event of a controller component failure;
 - Be supplied as a composite unit by one of the approved suppliers listed in the appendices.
- 17.7.9. Thyristors shall be rated to withstand five times the motor running current for five seconds with natural air ventilation in an ambient temperature of 40 degrees C, and for a minimum peak reverse voltage of 1300V. Printed circuit boards shall be plug-mounted into sockets for ease of maintenance.

18. TESTING AND COMMISSIONING

18.1. General

- 18.1.1. The Electrical Contractor shall undertake a full and comprehensive testing regime of the system in accordance with the requirements of BS 7671: 2018 Requirements for Electrical Installations IEE Wiring Regulations – latest edition in order to demonstrate that the system is in accordance with the Regulations.
- 18.1.2. All parts of the electrical installation shall be tested and commissioned to ensure safe and correct functioning throughout – together with demonstrating its compliancy with BS 7671.
- 18.1.3. Testing shall be undertaken using calibrated equipment and copies of the calibration certificates shall be included in the building manuals.
- 18.1.4. A Completion Certificate in conformance with the ECA or NICEIC, record drawings, circuit charts and details of installed plant and equipment shall be incorporated into an Operating & Maintenance Manual (O & M).
- 18.1.5. Testing, inspecting and commissioning shall be carried out in accordance with the requirements of the IEE Regulations. The testing, inspecting, commissioning shall be carried out upon completion of the installation, with witness tests being carried out by the checking Building Services Engineer where requested.
- 18.1.6. In order for these tests to take place, the Contractor shall complete the installation and satisfy himself that the installation has been carried out in accordance with the requirements of the Specification and drawings, and only when he is satisfied that the installation is fully operational in accordance with these requirements shall he offer the installation to the checking Building Services Engineer for witnessing.
- 18.1.7. The Contractor shall satisfy himself of the full operational requirements of each and every system covered by the electrical services specification, and for each system shall prior to carrying out the testing and commissioning submit to the Checking Building Services Engineer a fully detailed method statement indicating in detail the sequence of testing to be undertaken. Each task identified in the method statement shall clearly indicate the required result or results, if more than one operation/output is applicable when the system is operating correctly.
- 18.1.8. The method statement shall clearly indicate all tasks that are to be undertaken to satisfactorily demonstrate the whole system is operating correctly in accordance with the specification and shall include the proving of all interlocks, remote signals, all inputs, outputs, etc.

- 18.1.9. The testing and commissioning shall include all items of equipment and systems and any defect found on any item of equipment or system shall be rectified by the Contractor at no cost to the contract.
- 18.1.10. The Contractor shall test and commission all electrical services associated with the Mechanical services and ensure all services work are in accordance with the Mechanical Design.
- 18.1.11. The Contractor shall carry out the checks/inspections, but not be limited to those listed below:
- Size and type of mechanical control panels as specified
 - Fuses in main control panels of size and type specified
 - Size and type of all control units as specified
 - MCCB/MCB/HRC of size and type specified
 - All protective devices located in the phase conductor only and single pole switchgear not connected in neutral conductor
 - The location and erection of switchgear does not present a fire hazard
 - All equipment arranged to facilitate access
 - Check that protection against direct contact is achieved by barriers or enclosures is achieved on all equipment
 - Isolation provided (as specified)
 - Means of switching off for maintenance (as specified)
 - Check that actual current flow is not in excess of design value
 - Identification of control panels
 - Check connection of protective conductors and the preservation of electrical continuity
 - Enclosure of all switchgear shall not, in itself, be used a protective conductors
 - Check all terminations are mechanically and electrically sound
 - The check rotation of mechanical plant

19. POWER FACTOR CORRECTION

19.1. General

- 19.1.1. The Contractor shall supply, install, test and commission a power correction unit in accordance with the following listed standards, unless otherwise stated within the particular specification.

19.2. Standards

- 19.2.1. The power factor correction unit will conform to the following standards. This list is not exhaustive.
- BS1650: 1971 & AMD6461: Specification for capacitors for connection to power frequency systems.
 - BS 7264: Shunt capacitors for A.C. power systems having a rated voltage above 1000v.
 - IEC 831-1: Shunt power capacitors of the self-healing type for A.C. systems having a rated voltage up to and including 660V.

19.3. Operating Conditions

- 19.3.1. The power factor correction equipment shall be suitable for operation for a 415V ac $\pm$ 6% three phase 50 Hz $\pm$ 4% 4 wire supply. The waveform may be non-sinusoidal.
- 19.3.2. The power factor correction units shall be located in the positions shown on the design drawings layout.
- 19.3.3. The unit will be suitable for operation within a temperature ranges between 5 - 40 degrees C.
- 19.3.4. The unit must be capable of withstanding a maximum fault level of 35KA for 1 second.

19.4. Enclosures

- 19.4.1. The power factor correction equipment will be housed in a purpose made mechanically rigid floor standing cubicle/cubicles and will be fabricated from 1.2mm Zintec steel and finished in a powder coating Epoxy paint.
- 19.4.2. The final paint colour will be to match the main L.V switch panel, and will be advised at a later date. (The colour will be either a BS or RAL colour).
- 19.4.3. The cabinets will be constructed to provide a protection of not less than IP42.
- 19.4.4. Access to each cubicle is to be via a hinged or bolted access cover(s), and access is to be gained only by the use of a tool.
- 19.4.5. All metal components of the cubicle are to be adequately earthed. In the case of hinged doors this is to be via a 4mm sq. conductor connected to an earthing stud terminal, fixed firmly to each door.

- 19.4.6. The enclosure will be floor mounted and adequate fixing points shall be provided.
- 19.4.7. The enclosure will be so designed for front access only for maintenance and installation purposes.
- 19.4.8. An adequate number of suitable rated lifting lugs will be provided to allow easy installation of this unit. Each such point will be equipped with a label giving the maximum capacity.
- 19.4.9. Interconnections within the enclosure shall be sized for the lowest losses and may be cable or busbars. Busbars will be fully insulated with shrinkable P.V.C sleeving.
- 19.4.10. Control wiring shall be black and be not less than 1.5mm cross sectional area. Sharp tight bends will be avoided, and if it is necessary to bunch wiring, it shall be enclosed in trunking/conduit. The maximum number of cables within a bunch shall be limited to 12.
- 19.4.11. All connections/terminals will be as far as reasonably practical shrouded to prevent accidental contact with energised parts, when access panels are open.

19.5. Capacitors

- 19.5.1. Capacitors are to be of the dry type.
- 19.5.2. The element capacitors shall be made with a di-electric of metallised low loss self-healing polypropylene film having a graduated profile across the element width. The elements shall be housed within an ageless metal or plastic container, of low flammability and self-extinguishing.
- 19.5.3. This container will be encapsulated with a filling. This filling shall not:-
 - Cause an explosion
 - Cause a fire or support combustion
 - Constitute a Dermatological Hazard
 - Emit toxic or noxious fumes if heated or ignited
 - Constitute a hazard to the environment
- 19.5.4. THE USE OF POLYCHLORINATED BIPHENYL SHALL NOT BE ACCEPTABLE UNDER ANY CIRCUMSTANCES.
- 19.5.5. Prior to encapsulation the element windings should receive a specialised liquid heat treatment under vacuum to ensure perfect electrical characteristics.
- 19.5.6. The mechanical assembly of the elements within the container should incorporate thermal equalisers to ensure low operating temperatures for the elements.
- 19.5.7. The enclosure incorporating the required number of capacitor elements should be filled with inorganic, inert and non-flammable granules to absorb the energy of any non-permissible overload.
- 19.5.8. Each element capacitor will have its own internal fuse that is inaccessible without destroying this element capacitor.
- 19.5.9. Additionally each element capacitor will have an internal tamper proof pressure release device, and a discharge resistor to reduce the voltage to less than 50V in less than 60 seconds.

19.6. Controls

- 19.6.1. The capacitor shall be fully automatic and be switched in 25KVAR stages, unless detailed otherwise.
- 19.6.2. The total capacitor rating of each bank shall be in a number of separate equal parts. Each part shall be brought into line automatically to suit the need at any time.
- 19.6.3. Each stage will be brought into action by the use of suitably rated contactors controlled by a VAR sensitive relay. The relay itself shall be incorporated within the cubicle.
- 19.6.4. The relay shall be fitted with a loss of voltage no-volt release re-setting feature such that the switching sequence resets itself to an all contacts open position following a failure of supply.
- 19.6.5. Each contactor will be controlled via a rotary switch giving the following actions;-
 - Automatic Operation
 - OFF
 - Manual Operation
- 19.6.6. Each stage will have its own circuit protective device, and shall be suitably rated miniature or moulded case circuit breakers.
- 19.6.7. Each capacitor will have the following controls/indicators.
 - Red indicator lamps (6.5V via step down transformer).
 - Power factor meter with a scale of 0.5 lagging to 0.5 leading (unity to be mid-scale).
 - Selection for setting of desired power factors.
 - System fault.

19.6.8. In addition 3no. Volt free contacts will be allowed for fault conditions to a remote monitoring system.

19.7. Connections

- 19.7.1. Connection to the power factor correction unit will be via a 4 core, XLPE/LSF/SWA/LSF cables. The manufacturer shall install a gland plate for such a termination.
- 19.7.2. The supply will be top entry and will terminate into a suitably rated isolating switch which shall be mechanically interlocked with the access cover(s).
- 19.7.3. Sufficient space shall be allowed for the connection of the supply cables to the terminals.
- 19.7.4. All internal and external connections should be adequately rated and fully insulated.

19.8. Testing and Commissioning

- 19.8.1. The Contractor shall provide the routine and type test certificates for the power factor correction equipment cubicle. The tests shall be those listed in the relevant standards.
- 19.8.2. Routine tests shall be carried out on all switchgear/components as specified in the relevant standards listed. The Contractor shall allow to fully commission the system once installed on site.
- 19.8.3. The Contractor shall allow for witness testing at the manufacturers works, before the units are delivered to site.

APPENDIX A – SCHEDULE OF MANUFACTURERS

Item	Manufacturer	Notes
Fire Stopping (proprietary)	Rockwool 3M	For accessory boxes in fire partitions
Floor Mounted Electrical Panels	Schneider Mardix AF Switchgear GR Electrical ABB	
Wall Mounted Electrical Panels	Schneider Eaton Hager Legrande ABB	
Distribution Boards	Schneider Eaton Hager MK Crabtree ABB	
Air Circuit Breakers	Schneider ABB GEC	
Surge Protection	FJ Furse Limited	
Isolators	MEM ABB Schneider	
Sub Main Cables	Drakka Pirelli AEI	
Wiring Accessories	MK Ashley Clipsal Legrande	White Plastic – Logic Plus Range Metalclad to plant rooms, ceiling voids etc. (To be agreed with client)
Underfloor Busbar System	Electrak Legrande	Bus Bar track, tap offs, boxes, grommets and desk modules.

UPS Systems	APC UPSL Emerson Bori Riello	
Final Circuit Cables	Drakka Pirelli AEI	
Lighting Controls	CP Electronics Ashley Klix Danlers	
Fire Alarm	Apollo Zitron Clymac Gent	
Disabled Alarm	C-tec Clymac	
Refuge alarm	Clymac Chanel Cooper	
Access Control	BPT Paxton Access Videx	
Intruder Alarm	Galaxy Astec Systems Limited	
Cable Trays/ Trunking	Metsec Unistrut Swift Davies	

APPENDIX B – BENCHMARK STANDARDS

Selected relevant standards (table not exhaustive or exclusive)		
Standard	Short Description	Application Guidance
Building Regulations Approved Document B Volume 2	Fire Safety	Guidance for fire safety in Buildings other than dwellings
Building Regulations Approved Document F	Ventilation	Guidance on building ventilation, including building air quality and preventing condensation in a domestic or non-domestic structure
Building Regulations Approved Document G	Sanitation, hot water safety and water efficiency	Guidance for compliance of cold and hot water services with Building Regulations
Building Regulations Approved Document H	Drainage and waste disposal: Approved Document H	Guidance for compliance of drainage systems with the Building Regulations
Building Regulations Approved Document L Volume 1	Conservation of fuel and power	Guidance for the conservation of fuel and power in dwellings
Building Regulations Approved Document L Volume 2	Conservation of fuel and power	Guidance for the conservation of fuel and power in buildings other than dwellings
Approved Document M Volume 2	Access to and use of buildings	Guide to the ease of access to, and use of, buildings, including facilities for disabled visitors or occupants
BESA DW143	Ductwork air leakage testing.	Requirements for air leakage of ductwork and pressure testing procedures
BESA RAC80	Design Specification For DX Packaged Air Conditioning Equipment in buildings	Guidance to sizing, selecting and installing DX packaged air conditioning systems
BESA TR11	Use of plastic pipework	Guidance for the use of plastic pipework
BESA TR20	Installation and testing of hot water services	Requirements for the installation and testing of pipework systems in commercial buildings
BESA TR30	Heat Pump installations	Guidance to the specification and design of heat pump systems for heating and cooling in buildings.
BESA TR6	Site pressure testing of pipework	Requirements for the procedures for site pressure testing of pipework systems
BS 12897	Water supply. Specification for indirectly heated unvented (closed) storage water heaters	Requirements for water heaters installation
BS 3871	Miniature Circuit Breakers	Specification for miniature and moulded case circuit-breakers. Miniature air-break circuit-breakers for a.c. circuits
BS 4514	Unplasticized PVC soil and ventilating pipes of 82.4 mm minimum mean outside diameter	Requirements for PVC soil and ventilating pipes, fittings and accessories

Selected relevant standards (table not exhaustive or exclusive)		
Standard	Short Description	Application Guidance
BS 4533	Luminaires	Multi part document dealing with all requirements regarding luminaires
BS 4752	Moulded Case Circuit Breakers	Specification for switchgear and controlgear for voltages up to and including 1000 V a.c. and 1200 V d.c. Circuit-breakers.
BS 5266	Emergency lighting code of practice	Detailed guidance on the application and practice of emergency escape lighting, with a view to ensuring safety in the event that normal lighting is interrupted.
BS 5422	Method for specifying thermal insulating materials for pipes, tanks, vessels, ductwork and equipment operating	Requirements of thermal insulation
BS 5839	Fire detection and fire alarm systems for buildings.	Code of practice for design, installation, commissioning and maintenance of fire detection and fire alarm systems in non- domestic premises
BS 6004	PVC Insulated Cables. (non- armoured)	Electric cables. PVC insulated and PVC sheathed cables for voltages up to and including 300/500 V, for electric power and lighting
BS 6121-5	Mechanical Cable Glands.	Mechanical cable glands. Code of practice for selection, installation and inspection of cable glands and armour glands
BS 6724	LSF Thermosetting Insulated Cables. (armoured)	Electric cables. Thermosetting insulated, armoured cables for voltages of 600/1000 V and 1900/3300 V, having low emission of smoke and corrosive gases when affected by fire
BS 7211	LSF Thermosetting Insulated Cables. (non- armoured)	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 7346	Smoke control systems	Code of practice for planning, design, installation, commissioning and maintenance of smoke controls systems
BS 7671	IET Wiring Regulations	Requirements for Electrical Installations
BS 7942	Thermostatic mixing valves for use in care establishments.	Requirements and test methods of Thermostatic mixing valves
BS 8558	Complementary guidance to BS EN 806	Guide to the design, installation, testing and maintenance of services supplying water for domestic use within buildings

Selected relevant standards (table not exhaustive or exclusive)

Standard	Short Description	Application Guidance
BS 9999	Fire Safety	Code of practice for the fire safety design and management and use of buildings
BS EN 1057	Copper and copper alloys.	Requirements for copper pipework carrying hot water in sanitary and heating installations
BS EN 12056-2	Gravity drainage systems inside buildings. Sanitary pipework, layout and calculation	Design, calculations and layout of waste services
BS EN 12201-2	Plastics piping systems for water supply, and for drainage and sewerage under pressure. Polyethylene (PE). Pipes	Requirements for PE pipes carrying incoming water
BS EN 12449	Copper and copper alloys. Seamless, round tubes for general purposes	Material Specification for copper pipework carrying refrigerant
BS EN 1253	Gullies for buildings	Requirements for trapped floor gullies
BS EN 1254-4	Copper and copper alloys. Plumbing fittings.	Requirements for fittings combining other end connections with capillary or compression ends
BS EN 12845	Fixed firefighting systems	Design, installation and maintenance of Automatic sprinkler systems
BS EN 16005	Power operated pedestrian door sets.	Requirements and test methods of power operated pedestrian door sets
BS EN 274	Waste fittings for sanitary appliances.	Requirements for fittings, traps, overflows for waste systems
BS EN 60335-2-21	Household and similar electrical appliances. Safety. Particular requirements for storage water heaters	Safety requirements for hot water heaters
BS EN 60529	Classification of degrees of protection by enclosures.	Describes a method for classifying degrees of protection provided by enclosures, principally for electrical equipment.
BS EN 61534	Powertrack systems	Requirements and tests for powertrack systems
BS EN 62305-1	Protection against lightning.	General principles for the protection of structures against lightning, including their installations and contents, as well as persons
BS EN 806	Specifications for installations inside buildings conveying water for human consumption.	Requirements and recommendations for the design, pipe sizing, installation of potable water services
BS EN ISO 12241	Thermal insulation for building equipment and industrial Installations.	Calculation rules of thermal insulation for building equipment
BS800	Requirements for the interface level of equipment which may cause interference to radio reception.	Specification for radio interference limits and measurements for household appliances,

Selected relevant standards (table not exhaustive or exclusive)		
Standard	Short Description	Application Guidance
	which may cause interference to radio reception.	portable tools and other electrical equipment causing similar types of interference
BSRIA BG Guide	Commissioning of air systems	Guidance to commissioning of ducted air distribution systems in buildings
CIBSE Code A	Air distribution systems	Guidance to the commissioning of air distribution systems
CIBSE Code C	Automatic controls	Guidance to the commissioning of automatic controls
CIBSE Code L	Commissioning Lighting	Guidance to the commissioning of lighting and associated controls
CIBSE Code M	Commissioning Management	Guidance to the management arrangements required to ensure that building services systems are commissioned to meet compliance with the objectives of Part L of the Building regulations
CIBSE Code R	Refrigeration systems	Guidance to the commissioning of refrigerating plant and systems used in air conditioning applications
CIBSE Guide A	Environmental design	Guidance on external conditions; Guidance on the comfort criteria of the Thermal, Visual, Acoustic environment
CIBSE Guide B	Heating, Ventilation, Air Conditioning and Noise	Design guidance of HVAC systems including noise control
CIBSE Guide G	Public Health and Plumbing Engineering	Guidance for design and installation of PH services
CIBSE Guide H	Building control systems	Guidance for the design and installation of automatic building control systems
CIBSE Guide K	Electricity in Buildings	Guidance on load assessments, supplies, distribution, wiring systems, UPS, earthing, inspection and testing
CIBSE Guide TM13	Minimising the risk of Legionnaires disease.	Guidance on design, operation, maintenance and monitoring of water systems to minimise the risk of infection from Legionella Bacteria
CIBSE Guide TM31	Building logbook toolkit	Guidance to the development of the building logbook
CIBSE Guide TM39	Building energy metering	Good practice requirements for the provision of sub-metering
CIBSE Lighting Guides	CIBSE Lighting Guides	Good practice guidance to the design of lighting
DW 144	Specification for sheet metal ductwork	Specification for the manufacture and installation of sheet metal ductwork
DW/TR19	Internal cleanliness of ventilation systems	Requirements for testing of cleanliness for both new and existing ventilation systems and cleaning procedures

Selected relevant standards (table not exhaustive or exclusive)		
Standard	Short Description	Application Guidance
HSE L8 ACOP	Legionellosis Approved Code of Practice	Guidance on managing risk from exposure to Legionella bacteria
IEC-947	Low voltage switchgear and control gear	Regulations regarding selecting switch gear.
Institute of Plumbing Design Guide	Plumbing Engineering Services Design Guide	Guidance for design and installation of PH services

APPENDIX C - LIST OF REGULATIONS AND STANDARDS

- All British Standard Specifications.
- All British Standard Codes of Practice.
- The Health and Safety at Work Act.
- Recommendations of the Health & Safety at Work Executive.
- Factories Act.
- Offices, shops and railways premises act.
- Electricity Acts including Electricity at Work Regulations.
- Water and gas safety regulations.
- Local Byelaws and Regulations.
- Requirements of the Building Control Office, Building Regulations (specifically including Part L), Fire Officer and Environmental Health Officer.
- The Employers Insurers.
- BS 7671 (latest edition) The Wiring Regulations, including all amendments and appendices.
- Clean Air Act 1993
- The Control of Pollution Act 1974
- Control of Pollution (Amendment) Act 1989
- Workplace (Health, Safety and Welfare) Regulations 1992
- The Construction (Design and Management) Regulations 2015
- COSHH.
- IEC Standards
- Healthcare Technical Memorandums (particularly 06-01, 06-02, and 08-02)
- Construction Product Regulations (CPR) EU 305/2011 for the reaction to fire performance of products and materials, including all cables, to a Euro Class category rating of Cca in accordance with EN50399 and EN50575 (unless alternative proof of compliance to CPR is provided).

Euroclass Level	Description	Example Environment
B2ca	Very high fire protection, self- extinguishing	Hospital Wards, children's nurseries, above fire exits, designated escape routes in public buildings, airports, train stations, underground stations.
Cca	High fire protection, self- extinguishing	Hospitals, commercial buildings, leisure facilities, hotels, schools, administration and office buildings.

- All documentation, regulations, guides, technical memoranda etc. produced by the Chartered Institution of Building Services Engineers.
- Construction (Design and Management) Regulations 2015
- BS EN 50110 Operation of electrical installations. General requirements
- Provision and Use of Work Equipment Regulations 1998
- Personal Protective Equipment at Work Regulations 1992
- The Construction (General Provisions) Regulations 1961
- The Construction (Lifting Operations) Regulations 1961
- Other relevant Safety Regulations
- Public Utility Company and/or Statutory Authority regulations, specifications, and requirements
- British Standards and Codes of Practice
- Local Authority Regulations and approvals.
- BSRIA Commissioning Codes
- Manufacturer's stipulations and recommendations for installation, testing, commissioning and maintenance.
- Disability Discrimination Act.

APPENDIX D – DEFINITIONS

TERM	DESCRIPTION
A	Ampere
AC	Alternating Current
AHU	Air Handling Unit
AV	Audio Visual System
BOH	Back of House colleague and storage areas not accessed by customers
BSEN ISO	BS denotes Britain's National Standards. EN denotes a Standard adopted by the Europe controlled by the European Committee for Standardisation (CEN). ISO denotes a worldwide standard issued by the International Organisation for Standardisation
CCTV	Close Circuit Television
CIBSE	Chartered Institute of Building Services Engineers
COSHH	Control of Substances Hazardous to Health - the UK law that requires employers to control substances that are hazardous to health.
CPC	Circuit Protective Conductor
CPR	Construction Product Regulations
DB	Distribution Board
dB (A)	Noise generated over ambient, given as a rating
DC	Direct Current
DIP	Design Intent Package
DNO	Distribution Network Operator
DP	Double Pole
DX	Direct Expansion
ELV	Extra Low Voltage
FOH	Front of House, the sales area of a Demo Store
FCU	Fan Coil Unit
FFL	Finished Floor Level
GA	Global Architects
GC	General Contractor
GFOM	Global Fit Out Manual
Hz	Hertz, Electrical Frequency
HSE	Health and Safety Executive
IP	Ingress Protection
HVAC	Heating Ventilation and Air Conditioning
ITAB	Dyson Demo preferred lighting manufacturer, designer and supplier

K	Kelvin (as used to define colour temperature of lighting)
kVA	Kilovolt-Amp
kVAh	Kilovolt-Amp Hour
kW	Kilowatt, unit of electricity
kWh	Kilowatt Hour, unit of electricity
LD/A	Local Designer/Architect
LED	Light Emitting Diode
LRV	Light Reflectance Value
LSC	Luminaire Supporting Coupler
LSF	Low Smoke and Fume Cable
LSOH	Low Smoke Zero Halogen Cable
LSX	Low Smoke Zero Halogen Screened Multicore Cable
Lux	SI derived unit of illuminance
LV	Low Voltage
MCB	Miniature Circuit Breaker
MCCB	Moulded Case Circuit Breaker
MCP	Mechanical Control Panel
MEP	Mechanical/Electrical/Plumbing
NR	Noise Rating
PA	Public Address System
PH	Public Health
PIR	Passive Infrared (Sensor)
PM	Project Manager (Dyson)
O&M	Operation and Maintenance (Manual)
RAL	Colour matching system used in Europe
RCBO	Residual current circuit breaker with overcurrent protection
RCD	Residual Current Device
RDT	Dyson in house Retail Design Team
SCA	Smoke Control Association
SWA	Steel Wire Armoured
TMV	Thermostatic Mixer Valve
HWS	Hot Water Services
V	Volt
VCD	Volume Control Damper
VRF/VRV	Variable Refrigerant Flow / Variable Refrigerant Volume
WRAS	Water Regulations Advisory Scheme