

Standard Specification for the Electrical Engineering Services

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1.0 General Technical Requirements

1.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK, then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
UK HSE	Construction (Design and Management) Regulations
UK Gov Legislation	Electromagnetic Compatibility Regulations
UK Gov Legislation	Control of Electromagnetic Fields at Work Regulations
BS 7671	Requirements for Electrical Installations
BS EN 62305	Code of Practice for Protection of Structures Against Lightning
ENA Engineering Recommendation G5/5	Harmonic voltage distortion and the connection of harmonic sources and/or resonant plant to transmission systems and distribution networks in the United Kingdom
ENA Engineering Recommendation G99/1 and G100	ENA Engineering Recommendations G99/1 Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019 ENA Engineering Recommendations G100. Technical Requirements for Customer Export Limiting Schemes
BS EN 547 series	Safety of machinery. Human Body measurements. Anthropometric data
BS 5950	Structural use of Steelwork in Buildings CP3: Chapter V, Part 2 Wind Loads (as cited in Building Regulation Guidance)
BS EN 1090	Execution of Steel Structures and Aluminium Structures. Technical Requirements for Steel Structures.
BS 648	Schedule of Weights of Building Materials (as cited in Building Regulation Guidance)
BS 6399	Design Loadings for Buildings (as cited in Building Regulation Guidance)
BS EN 1991-1	Eurocode 1 Actions on Structures

1.2 Related Specifications

This specification is the Standard Specification for Electrical Engineering Services installations for the proposed development. The specifications form part of the Employers Requirements.

Specifications are subdivided into the following categories:

- **Standard Specifications:** Documents that define the general specifications for plant, equipment, system and workmanship and materials standards as well as General Requirements and Preliminaries. Documents that provide details of the contract requirements.
- **Particular Specifications:** Documents that provide prescriptive project specific requirements. They provide a description of the installations, operation and control of the works. (They may include portions that require further design.)
- **Performance Specifications:** Documents that provide project specific requirements that require further design. They define the operational requirements of the installations.
- **Equipment Schedules:** Documents that provide project specific equipment requirements such as technical performance criteria and dimensional information.

1.3 Conflict between Specifications

The Particular Specifications and Equipment Schedules will take precedence in the event of conflict between specifications.

Any potential conflict between the specification and legislation, statutory documents, approved documents or approved codes of practice, shall be notified to the Engineer in accordance with the tender or contract technical query or Request for Information (RFI) procedures.

1.4 Definition of Terms and Abbreviations

For further information on Terms and Abbreviations please refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

For the purposes of this document, the following terms and definitions apply.

1.4.1 GUI

Graphical User interface, an interface between the operator and the system that graphically presents system information and operator functions.

1.4.2 HMI

Human machine interface, including input and output devices, in which the output devices may be indicators, alphanumeric or graphical displays.

1.4.3 ICT

Information, communication technology applications, the scope including the transmission, emission, and reception of signs, signals, writing, images and sounds by cable, radio, optical or other electromagnetic systems.

1.4.4 Traffolyte

A type of label, notice or sign formed from laminated layers of individually coloured thermoplastic, the outer layer being engraved to show lettering and symbols in the colour of the layer below.

1.4.5 Electricity Company

The Electrical Utility Service provider comprising of all organisations necessary to provide an electrical utility service to the premises. These include the parties responsible for providing the physical infrastructure for the generation, transmission and distribution of the electricity service to the ultimate supply point and those responsible for managing the delivery and metering of electricity to consumer or prosumer electrical installations using that infrastructure.

The term may include, but is not limited to:

- Aggregators
- Building Network Operators (BNOs)
- Distribution Network Operators (DNOs)
- Independent Connection Providers (ICPs)
- Independent Distribution Network Operators (IDNOs)
- Metering System Operators (MSOs)
- Smart Metering System Operators (SMSOs)

- Transmission systems operators (TSOs)

1.5 General Requirements

This specification shall be read in conjunction with the Architectural, Civil, Structural, Mechanical, Electrical, Public Health, Fire and ICT drawings, other relevant specifications and contract documentation, preliminaries, etc, that make up the contract documents and as listed in the issue register, which are relevant to the specific work element.

The Contractor shall be responsible for the design, supply, installation, testing and commissioning of the specified engineering installations detailed in the documents and shall meet all the parameters specified and requirements detailed within the design documentation, drawings and specifications. Wherever the term 'Contractor' is referred to within this specification, this shall denote the Contractor for the works package being described.

The Mechanical, Electrical, Public Health, BMS, Fire and ICT Engineering Specifications and drawings are issued to indicate the principles of the system design, design criteria and client's requirements. They do not attempt to detail every system component and it is the responsibility of the Contractor to ensure that he has included within their costs for all items necessary to meet the requirements of the specifications, drawings, engineering design intent and Employer's requirements.

The work shall be complete in every respect and the Contractor shall include for all items, though some may not be particularly specified, to ensure that the work shall be complete in every detail for the sum stated in the Tender.

No claims for extras shall be considered unless specific instructions have been issued in writing by the Employer's Agent to execute works additional to the Contract.

1.6 Legislation and Standards

All of the equipment detailed within this specification and on the drawings shall be manufactured and installed in full compliance with the latest edition of all relevant British, European, International and local standards, Codes of Practice and Regulations applicable to the country of the installation wherever they are more stringent. It is the responsibility of the Contractor and their supply chain (sub-Contractors and equipment suppliers) to document this.

1.7 Statutory Requirements

The Contractor shall be responsible, and shall make due allowance, for giving all notices and attendance for inspection to the Utility Service Providers and the Local and Public Authorities. These requirements include obtaining all necessary consents and paying all fees legally demandable.

The Contractor shall be satisfied and confirm, in writing, that the whole of the installation is in accordance with the Byelaws, Building Regulations, Building Control and regulations of the Local Authority having jurisdiction, the requirements of the Public Health Officer, the Regional Electricity Company / Network owner / Manager, the Fire Brigade and all interested parties.

Authorities shall be notified as necessary about the connection of all utility supplies.

Liaise with the Statutory Authorities and provide any test notices required to ensure final connections are made in accordance with the requirements of the programme. Specifically, with respect to meet the testing and commissioning requirements.

Provide all formalities in connection with Test Notices, Agreement and Application for Supply Forms etc. Ensure all documents requiring the Employer's signature are forwarded to the Employers Agent in time to

meet the building programme in order for the necessary test and supply arrangements to be made. No additional payments will be made for expenses incurred due to reconnections, re-visits etc., by Supply Authorities or any other officials.

Any such portion of the works requiring the inspection and approval of all relevant regulatory authorities and utility companies shall not be built in, covered or otherwise obscured until such approval has been obtained. Any additional costs incurred by the Contractor for non-compliance with this clause shall be borne by the Contractor.

1.8 Precedence

The requirements of legislation shall take precedence over those of approved documents and approved codes of practice.

The requirements of approved documents and approved codes of practice shall take precedence over those of national standards (in general, British Standards).

The requirements of national standards shall take precedence over those of regional standards (in general, European Norms).

The requirements of regional standards (in general, European Norms) shall take precedence over those of international standards and standards of other countries.

In the event of there being discrepancies between the Standards, Regulations etc., or between this Specification and the Standards, Regulations, etc., the most stringent shall be deemed to apply.

1.9 Regulations, Standards and General Parameters

Provide all materials and works in accordance with the appropriate British Standard or Code of Practice, European Standards, EU Commission Regulations or other Local Standards. Where no Standard or Code of Practice is applicable the comply with the Agreement Certificate for the particular item.

Provide products in accordance with the Construction Products Regulations (CPR). Products covered by harmonised European product standards (hENs) must have a Declaration of Performance (DoP) certificate for the product and be CE marked. Manufacturers of products not fully covered by a hEN or which do not fall within the scope of a hEN shall provide Declaration of Performance documentation in accordance with one of the methods in the CPR.

Comply with all statutory instruments and regulations, relating to the area of the site current at the date of tender.

Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK, then any British Standard list shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

This specification is based on UK and European Standards, to achieve an approach for safety and compatibility for electrical, data network and information technology installations, and equipment, aligning with the European Committee for Electrotechnical Standardisation (CENELEC) approach.

Identify any instances where the proposed solution does not conform to the above.

Notify all authorities in accordance with their regulations and obtain any required approvals for the installation.

Where no specific design, performance or installation standards are quoted the following shall apply:

- CIBSE Guides
 - Guide A Environmental Design
 - Guide B Heating, Ventilating, Air Conditioning and Refrigeration
 - Guide C Reference Data
 - CIBSE the SLL Code for Lighting
 - CIBSE Technical Memoranda
- Chartered Institute of Plumbing and Heating Engineering, Plumbing Engineering Services Design Guide
- BSRIA BG Series

Ensure all equipment and systems are designed and installed in accordance with the relevant standards, manufacturers recommendations and that operational compatibility exists between the systems and any other system installed at the same location.

Supply plant and equipment to achieve the specified design conditions and to provide stable control. Modular or prefabricated plant and systems (e.g. prefabricated boiler house, fire pump system) shall be tested as a single assemble in according to the relevant BS / BS EN standards.

For insulation: comply with online guide to check long term impact of material selection - www.thegreenguide.org.uk

For further information refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.10 CDM Regulations

This project shall be executed under the Construction (Design and Management) Regulations or equivalent national health and safety regulations in the relevant country, and the Contractor shall be responsible for providing all required documentation to the Principal Designer and Principal Contractor for the project Health and Safety file.

The Contractor shall comply with the requirements of the CDM Regulations by:

- Adhering to the rules of the Pre-Construction Information and Construction Phase Plan
- Reporting accidents, injuries or dangerous occurrences to the Main Contractor
- Providing the main Contractor with appropriate input to the health and safety plan, including risk assessments, and to the health and safety file
- Providing the main Contractor with information on the contract works which might affect the health or safety of any person

1.11 Electrical Design Parameters

Specific design parameters are detailed elsewhere in this specification and other documents; however, the following general design considerations are applicable:

- All equipment must not be used in any way to exceed any rating declared by the manufacturer in its application
- The electrical installation must comply with ENA Engineering Recommendation G5/5 or equivalent national electricity network codes and guidelines

- The electrical installation must comply with ENA Engineering Recommendations G99/1 and G100 or equivalent national electricity network codes and guidelines
- Equipment installed in low voltage panels shall generally be at a height not exceeding 1800 mm from FFL and not below 300 mm from FFL
- Switches, cabling, and protective devices shall be rated more than the supply symmetrical and asymmetrical fault levels
- Surge protection shall be provided in accordance with BS 7671 and BS EN 62305. Supplies to sensitive equipment, i.e. BMS, IT, etc., shall have surge protection
- The whole of the electrical installation shall be arranged so that a fault will only cause one protective device to trip and selectivity is achieved
- Distribution or connection boxes must be accessible for maintenance
- Switchboards and panels must include a 20% minimum spare capacity. Boards must always be mounted on plinths at least 100 mm high. All switchgear must be designed to facilitate thermal imaging whilst live
- All manual/off/auto selector switches must be monitored to alarm via the SCADA/EMS if out of auto position is selected
- The Contractor shall ensure that all plant and equipment is installed such that it is fully maintainable. The electrical installation must cater for concurrent maintenance of all equipment and components without affecting the load

1.12 Materials and Workmanship

All materials and their workmanship shall be of the best quality of their respective kinds. All materials referred to in the Specification shall be subject to the Employers Agents approval and samples where requested shall form the standard of quality for all such materials used in the Works.

Where the quality of materials is not specified, they shall be the best of their respective kinds and shall be in accordance with any relevant British Standard Specification or local standard applicable and samples or full details shall be submitted to the Employers Agent for approval before use.

Should the Contractor wish to deviate in any way from specified items, they must do so in writing to the Employers Agent and obtain approval prior to submitting their priced Tender, otherwise they shall be held to have included for anyone of the specified manufacturers.

When such terms as 'equal' or 'equal and approved' are used alternative articles may be accepted, but shall only be submitted for consideration as an alternative to those specified and they shall then be scheduled with full details and price differences. The alternative articles may only be utilised after the Engineer has commented and agreed their use in writing.

The Employer's Agent may require the Contractor to submit correctly identified and documented samples of any materials or workmanship to be used in the Contract Works for their appraisal. The Contractor shall allow for any charges necessary in complying with this condition. All materials and workmanship for which samples have been accepted must conform in every respect with such samples, and any items not conforming to the accepted standard shall be removed and replaced with new materials at the Contractors own expense.

The complete installation shall be carried out in a neat and proper manner, particular attention being paid to the continuity of the whole system and sound and secure fixing of all materials and equipment. Under no circumstances will any inferior work be accepted by the Employers Agent or their appointed representative.

All plant materials shall be new and the Contractor shall ensure that no materials or equipment are fitted which show signs of corrosion or faults or are damaged in any way. Replacement of such plant or materials shall be at the expense of the Contractor.

1.13 Design Life

Refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.14 Compatibility

Refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.15 Obsolescence

Refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.16 Access and Maintenance

In the preparation of installation drawings and in the erection of the mechanical and electrical contract work, the contractor shall ensure that adequate provision is made for access to, operation and maintenance of the various valves, damper components, plant and equipment.

Systems that are fully accessible to facilitate the ease of maintenance. For the avoidance of doubt, access for maintenance of machinery, switchgear, control gear and generators shall comply with a suitable standard for accessibility, compliance with BS EN 547-series is a minimum requirement.

All plant and equipment shall be located for safe and proper maintenance. Access ways with handrails are to be provided to enable routine maintenance of high-level equipment. Protective guards are to be provided for all elements of the installation which are unsafe to touch.

Routine maintenance shall be possible without the removal or dismantling of other plant and equipment.

Provision shall be made so that apparatus which needs regular removal for maintenance may be removed with the minimum of its connection and without interference to other adjacent installations.

Services in ducts and in other voids shall be so arranged and secured that as far as is practicable, they will not prevent convenient access for the maintenance and renewal of any other service.

The installations shall be such that the equipment shall be easily maintainable using standard tools and equipment. The need to use specialist tools and equipment to carry out maintenance shall be avoided if at all possible.

Provision of access shall be deemed to provide for installation, testing/commissioning, identification and future maintenance/replacements.

1.17 Electrical Characteristics

Ensure that electrical characteristics of component parts of assemblies are as indicated and apply when components are installed in their final environment, including, where necessary, mounting in any enclosures. Allow appropriate de-rating factors for effect of ambient temperature conditions, enclosures, other components, and inter-connections.

For further information refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.18 Electromagnetic Compatibility and Electromagnetic Fields

Ensure that the installation complies with the Electromagnetic Compatibility Regulations. Ensure all equipment and systems are installed to provide electro-magnetic compatibility within the systems and with any other systems installed in the same location.

Comply with the Control of Electromagnetic Fields at Work Regulations during the construction and commissioning of the works.

Ensure the completed works comply as necessary with the Control of Electromagnetic Fields at Work Regulations.

For further information refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.19 Explosive Atmospheres

Refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.20 Service Conditions

The engineering installations have been designed to fully withstand the ambient conditions detailed herein.

Special attention shall be paid to the selection of equipment positioned in direct sunlight, or certain artificial light sources, to account for temperature rise and damage caused by ultraviolet (UV) radiation.

All services and equipment shall be suitably rated to be compatible with the operational conditions and external influences it is intended to operate in, including but not limited to the degree of protection of electrical installations and equipment to persons, equipment, mechanical impact, and the ingress of water and solids.

In determining the ambient and operating temperature of equipment, temperature increases from installation conditions and adjacent equipment and services that emit heat, shall be taken into consideration when selecting the equipment, sizing cables, and verifying and validating protective devices.

Care shall be taken by the Contractor when selecting equipment that one item of equipment does not unduly affect an adjacent item of equipment due to its temperature rating.

1.21 Excluded Materials and Substances

Refer to P.100000-RED-XX-XX-SP-Z-8000 – General Technical Preliminaries for the Engineering Services.

1.22 Fixings and Supports

The Contractor shall be responsible for all fixings of all pipes, ducts, conduits, equipment and accessories which shall include the supply and installation of all rawlplugs and other plugs, bolts and rawlbolts, screws, suspensions, brackets, clamps, saddles, spacers, etc. and any other fixings whether or not specified, which may be required for the proper and effective fixing of material or equipment. The use of wooden plugs for fixing purposes will not be permitted.

Fixings by means of hardened steel pins driven in by percussion tool (HILTI or similar) or by gun fixing techniques shall not be allowed unless in exceptional circumstances and where specifically agreed in writing by the Employer's Agent.

Fixings to steelwork, etc. by means of special preformed spring clips or brackets will only be carried out after approval has been obtained from the Employer's Agent.

The Contractor shall ensure that every fixing installed and supporting structure is adequate to support and/or restrain the item of plant or equipment concerned, making all necessary allowance for the fixing and for the substance into which it is anchored or fixed.

Where fixings demand special brackets and similar, details of the proposed design shall be submitted to the Employer's Agent for agreement prior to manufacture as part of the working drawings.

The material of the fixings shall be compatible with the equipment they are supporting. Dissimilar metals shall not be used in an environment that will induce electrolytic action sufficient to cause deterioration of one of the metals.

The materials from which clips, ties, straps, cleats and brackets etc. are manufactured shall be resistant to common corrosive elements, ultra violet light, ozone, free from migration of plasticiser to the sheaths of cables and should not become brittle at low temperatures. Care should be taken with metal cleats etc. that damage does not arise from electrolysis between the cleat, its fixings or any adjacent metal.

Care shall be taken in the selection of proprietary clips to ensure that not only the weight of the item to be supported is in the direction for which the clip was designed to take strain but that also the clips is not dislodged by incidental forces from other directions.

All nuts, bolts and screws securing equipment shall be to British Standard dimensions and the use of fixings needing special purpose made screw drivers, spanners or keys shall be avoided, unless specifically required by the specifications.

Bolts, nuts and screws shall be either galvanised or made of non ferrous metal. Screws with damaged threads and/or damaged heads shall be replaced by the Contractor.

All fixing devices shall be of such a type and construction to safely carry the loading intended. Screws and bolts shall be of ample size and shall, in all cases, be of the requisite diameter to suit the orifice intended.

The threaded section of an installed expanded bolt fixing shall protrude through the equipment fixed to enable a nut, plain and serrated or springwasher to be fixed, leaving a minimum of 4mm of thread exposed.

In all cases where fixings, bracket work and other metal supports are exposed to the weather or damp or hostile conditions, they shall be suitably treated with an inhibiting substance or galvanised in accordance with the specifications or as directed by the Engineer. Under no circumstances will rusted or corroded metal work be installed.

No building frame or structural steel member may be cut, drilled or welded without having first submitted full details of such proposals to the Employer's Agent and having received written approval from the Structural Engineer via the Employer's Agent. It shall not be assumed within the Contractor's tender that such methods will be utilised.

Unless otherwise specified, all structural iron or steelwork shall be galvanised. All drilling, punching, cutting and painting of parts shall be completed and all burrs shall be removed before galvanising is carried out. Galvanising shall be applied by the hot dip process, the thickness of coating shall not be less than 915 g/sq.m. The zinc coating shall be smooth, clean, of uniform thickness and free from defects.

Preparation or other special processes shall not be used.

Care shall be taken not to abrade galvanised or specially treated surfaces.

All rust streaks or foreign matter deposited on galvanised surfaces during storage, transport or after erection shall be removed.

Fixings for heavy equipment to metal framework and other substantial structures shall be made using steel screws or bolts with nuts, plain and serrated or spring washers. Heavy equipment shall not be fixed by plugs or shot bolts without the written approval of the Employers Agent.

Lightweight equipment installed on a mild steel sheet structure shall be fixed by an appropriately sized set screw and must be complete with plain and serrated or spring washer.

Where a sheet steel structure is enclosed, fixings may be achieved by using a shakeproof self tapping screw of proprietary spring or gravity toggle.

Fixings to heavy gauge or cast metal shall be made using machine thread screws entered into holes tapped by the sub Contractor or at works. Tapped threads shall be achieved using the correct drill size with taper, second and plug taps.

Fixings to brick blockwork and concrete shall be made using an approved expanding bolt suitably sized and entered into a pre drilled hole of depth (exceeding thickness of render/finishes) equal to the length of fixing to be used.

Fixings may also be achieved in concrete structures by pre casting or grouting rag bolts.

Fixings to brickwork and blockwork shall be made in the bricks/blocks and not in the mortar joints. In items of equipment containing multiple fixing provisions, where it is impossible to make all fixings in the brick/block, then the equipment shall be positioned to enable the upper fixings to be made in the brick/block.

Fixing to enclosed hollow structures of soft or hard fibre boards etc. shall be made using proprietary spring or gravity toggles or equally approved. Under no circumstances shall such fixing methods be used in plasterboard or materials of a like nature, unless first approved by the Employers Agent.

Fixings to timber shall be made using steel woodscrews. When fixings occur in a damp or humid atmosphere or are exposed to the weather brass, galvanised steel or cadmium plated steel screws shall be used.

Equipment installed on a heavy wooden structure may be fixed using coach screws entered into correctly sized pre drilled pilot holes.

Heavy equipment shall be fixed by means of approved pattern clamp brackets, ragbolts or other patent methods of fixing.

Fixing support structures which are extended to floor level and restrict clear widths of corridors etc. shall not be permitted. No fixings into or through roofing materials will be allowed.

The Contractor shall be responsible for the safety and finish of all supports. Unnecessary sections shall be removed, excessive rod/bolt lengths removed etc. to avoid unnecessary protrusion and potential for injury.

The Contractor shall treat, seal and cap all open/cut ends and ensure that any works which present a potential injury access hazard are wrapped/padded/protected in a manner which reduced the potential hazard to the Employers Agent satisfaction.

Any exposed works below 2.1m shall be wrapped with coloured warning tape to highlight their hazard potential where they are located above access space.

1.23 Interface with Structure

The Contractor shall note the structural loading design allowances incorporated into the Structural Engineers calculations and ensure that their installation does not exceed these values.

The Contractor shall be responsible for the design, detailing, fabricating, supply, installation and statutory approvals of all secondary steelwork (as detailed below) or any other secondary structural work necessary to support, secure or otherwise connect the works within the contract to the primary structure.

The Contractor shall be responsible for any site surveys necessary to check the accuracy of the drawings with respect to the 'As Built' primary structure prior to carrying out any fabrication or installation of any secondary structural works.

Detail drawings and calculations for all secondary structural works shall be submitted for review prior to the fabrication or the installation of any secondary structural works.

All points of connections to the primary structure and the loads applied at these points shall be to the approval of the Employer's Agent via the Structural Engineer. The contractor is responsible for providing this information in a timely manner.

Secondary steelwork and fixings shall be designed in accordance with the requirements of the Building Regulations and all relevant Codes of Practice and British Standards including the following:-

- BS 5950 Structural Use of Steelwork in Buildings CP3 : Chapter V, Part 2 Wind Loads (as cited in Building Regulations Guidance)
- BS EN 1090 Execution of Steel Structures and Aluminium Structures. Technical Requirements for Steel Structures.
- BS 648 Schedule of Weights of Building Materials. (as cited in Building Regulations Guidance)
- BS 6399 Design Loadings for Buildings. (as cited in Building Regulations Guidance)
- BS EN 1991-1 – Eurocode 1 Actions on Structures

At all building expansion and construction joints, the Contractor shall install flexible couplings and movement provisions within their installations. The details of the couplings and provisions to be used shall be agreed with the Employer's Agent during the working drawing production stage.

2.0 Earthing

2.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
APEA / EI 'Blue Book'	Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4 th Edition.
BS 6701	Telecommunications equipment and telecommunications cabling, specification for installation, operation, and maintenance
BS 7430	Code of practice for protective earthing of electrical installations
BS 7671	Requirements for Electrical Installations
BS 7909	Code of practice for temporary electrical systems for entertainment and related purposes
BS 951	Specification for clamps for earthing and bonding purposes
BS EN 13601	Copper and copper alloys - Copper rod, bar, and wire for general electrical purposes
BS EN 50174-3	Information technology. Cabling installation. Installation planning and practices outside buildings
BS EN 50310	Application of equipotential bonding and earthing in buildings with information technology equipment.
BS EN 50522	Earthing of power installations exceeding 1 kV a.c..
BS EN 60079-14	Explosive atmospheres. Electrical installations design, selection and erection
BS EN 61936-1	Power installations exceeding 1 kV a.c. Common rules
BS EN 62305	Code of Practice for Protection of Structures Against lightning
BS EN 62561-1	Lightning protection system components (LPSC). Requirements for connection components
BS EN 62561-4	Lightning protection system components (LPSC). Requirements for conductor fasteners
BS EN IEC 62561-2	Lightning protection system components (LPSC). Requirements for conductors and earth electrodes.
BS EN IEC/IEEE 82079-1	how to prepare technical and instruction manuals and other product, equipment or software documentation
BS ISO 3864	Graphical symbols. Safety colours and safety signs. Design principles for safety signs and safety markings
ENA Engineering Recommendation G12/4	Requirements for the Application of Protective Multiple Earthing to Low Voltage Networks.
ENA Technical Specification 41-24	Guidelines for the design, installation, testing, and maintenance of main earthing systems in substations
ITU-T K.68	Telecommunication Standardization Sector of ITU recommendation, Series K: Protection Against Interference. Operator responsibilities in the management of electromagnetic interference by power systems on telecommunication systems

2.2 General

All exposed-conductive-parts and extraneous-conductive-parts shall be electrically and mechanically bonded to the consumer's main earth terminal and also, if applicable, to the lightning protection system or other points specified.

The systems shall consist of substation earthing, electrical systems earthing, equipotential bonding of other services and extraneous metal work

The earthing installation shall comply in every respect with the following: -

- BS 7671 Requirements for Electrical Installations
- BS 7430 Code of Practice for protective earthing of electrical installations
- BS EN 62305 Code of Practice for Protection of Structures against Lightning
- BS EN 50310 (implementing IEC 30129) Application of equipotential bonding and earthing in buildings with information technology equipment

Where protection against electric shock is provided by automatic disconnection of supply, provide all earthing conductors, connections and materials of sufficient current carrying capacity and strength so as to safely conduct an earth fault without causing danger within the operating time of the protective device. The earth fault loop impedance of each circuit shall be sufficient to ensure that the final circuit protective device will operate in the relevant disconnection time.

2.3 Earth Bars

A main earth terminal shall be supplied and installed adjacent to the incoming supply point and at each main switchboard. The terminal shall comprise a copper bar of minimum dimensions 50 mm (H) × 6 mm (D), insulated from masonry and conductive parts of the structure by proprietary insulators. The main earth connection shall be connected to the bar via a removable link. The terminal shall be in accordance with the design drawings to accommodate items of equipment such as switchgear, piped services, cable sheaths, lightning protection systems and metallic parts of the building structure. Extraneous-conductive-parts, including those specifically referred to, shall be bonded to this earth terminal using LSZH (Low Smoke Zero Halogen) green-and-yellow insulated cables coloured green-and-yellow, or LSZH insulated copper tape coloured or over-marked green-and-yellow in accordance with BS 7671.

On each and every protective and equipotential bonding conductor a flexible Traffolyte or LSZH, thermal transfer, thermal embossed durable label shall be provided. The label shall identify the particular bonding connection.

2.4 Bonding and Protective Conductors

Bonding and Protective conductors shall be sized in accordance with the requirements of the current edition of BS 7671.

A Traffolyte warning label complying with BS ISO 3864 and BS EN IEC/IEEE 82079-1 reading "SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE" in engraved upper-case characters not less than 5 mm high shall be permanently fixed immediately adjacent to or on the earth terminal.

All protective conductors required to have mechanical protection in accordance with BS 7671 shall, where possible, be enclosed within metal trunking or conduit serving switchgear, distribution board etc., so as to provide mechanical protection. Where suitably sized protective conductors are run on building surfaces, they shall be properly fixed and supported by means of appropriately sized cable cleats for round conductors and PVC coated metal saddles for flat type conductors. These conductors shall be routed in agreement with the engineer.

Auxiliary earth conductors associated with armoured type or sheathed cabling shall be routed alongside the respective cable and shall be securely fixed to the cable or containment system.

Green-and-yellow LSZH insulated copper fly leads shall be run between the earth terminals of every accessory/conduit box to the earth terminal on the accessory.

Where conduit boxes or conductive accessory boxes are not provided with proprietary earth terminals, an earth terminal shall be tapped into the base on the box, the tapping suitable to take an M4 brass dome head screw. The connection fly lead shall be of a cross section not less than the line conductor supplying the accessory.

Separate items of switchgear, distribution boards, etc., mounted adjacent to one another shall be connected by means of high conductivity continuous copper tape, or LSZH sheathed cable coloured green-and-yellow and sized in accordance with the current edition of BS 7671, connecting all items to the earth terminal.

All items of switchgear, accessories, luminaries, conduits and the outer sheaths of MICS cables, the armouring of all PVC/SWA/PVC, or XLPE/SWA / LSZH cables together with all other items of electrical plant and equipment shall be effectively earthed by means of a protective conductor in accordance with the current edition of BS 7671, particular attention being drawn to the requirements of earthing arrangements and protective conductors.

At every terminal point of the fixed wiring system an integral earth terminal shall be provided, e.g. BESA boxes, accessory boxes etc. A protective conductor shall be provided and installed between this terminal and the earth terminal on the associated switch, socket outlet, luminaire etc.

Each circuit protective conductor shall be connected to a multi-way earth terminal provided and fixed within each distribution board. The earth terminal shall be provided with an adequate number of ways such that not more than one conductor per terminal shall be installed and the earthing conductors shall be connected in the same sequence as the current carrying conductors, as well as accommodating connections for the respective bonding conductors and a connection to the main earthing terminal (MET).

All surfaces to which earth connections are made shall be cleaned free from paint and other non-conducting materials prior to the making of the earth connections. The surface shall be treated in accordance with good working practices to prevent corrosion appropriate to the environmental conditions.

The provision of all earthing and bonding materials whether or not specifically detailed within the specification or shown on the drawings necessary for the correct and proper installation in accordance with the standards, and associated standards, either specified or implied by applicable legislation, or connection or licensing conditions, shall be deemed to be included with the cost of supplying and installing that piece of equipment.

Unless specified otherwise, single core armoured cables shall utilise aluminium armour and the cable shall be bonded to earth at each termination. The gland plate for each single core armoured cable shall be manufactured from non-ferrous material with a minimum thickness that shall be in accordance with manufacturer's recommendations.

All conductive sheaths, braid, screens, armour, and integral catenary wires and strengthening elements of low voltage and ICT cables, including optical fibre cables, shall be bonded to earth at both ends of the cable unless otherwise detailed.

2.5 Main Protective Bonding

All extraneous mechanical services utilities such as main pipes, other service pipes and ducting, risers of heating and air conditioning systems and exposed metallic parts of the building structure shall be connected to the main earthing terminal by means of main equipotential bonding conductors.

Distribution boards that accommodate circuits of mixed disconnection times shall afford an equipotential bonding conductor to bond the utilities previously detailed. This shall apply to the respective zone that a distribution board serves.

A 50 mm section of each metallic service pipe either at positions close to the entry into the building or after any metering equipment shall be cleaned and made smooth. A proprietary copper earthing clamp designed to permit the connection of protective conductors shall be provided.

Connections to ducts and risers shall generally be made at flanges where at least two lock nut set screws shall secure each connection.

Earth clamps shall be constructed in accordance with BS 951.

Connection to exposed metallic parts of the building shall generally be made where sections are bolted together. Request extended bolts where necessary to provide an effective connection. Welded stud connections may be permitted, subject to approval of the Structural Engineer.

A Traffolyte warning label complying with BS ISO 3864 and BS EN IEC/IEEE 82079-1 reading "SAFETY ELECTRICAL CONNECTION - DO NOT REMOVE" in engraved upper case characters not less than 5 mm high shall be permanently fixed at the points of connection where BS 951 clamps and associated labels are not used.

Connections between dissimilar metals are to be avoided. Where this is unavoidable, electrochemical potentials shall be kept below 300 mV and they shall either have the faces chemically coated in accordance with good working practices to prevent electrolytic action, or a proprietary joint shall be used. In the event of copper being present it shall be tinned.

Joints in copper tape shall be tinned before assembly, riveted and then the joint shall be sweated. Where tapes are used, care shall be taken to ensure that the effective cross-sectional area of the tape is not compromised by drilling for fixing or jointing.

The protective and bonding conductors shall be fixed by means of PVC coated metal saddles. Earth tapes will be cleated to the structure via stand-off brackets providing a minimum clearance of 5 mm. All brackets shall be proprietary manufactured to suit the intended purpose.

The final connection of bonding conductors from gas, water pipes and other services to the earthing terminal shall not be completed until the Engineer has received satisfactory test results from the earth electrode and earth fault loop impedance tests.

Bonding connections to pipework shall be as unobtrusive as possible and where practicable shall be made in service ducts or accessible voids. The connections shall be readily accessible, and their positions shall be indicated on the record drawings.

All metal sheathing, armouring of cables, metal cladding of enclosed apparatus, metal cases of switch gear, generators, and frames of motors shall be electrically continuous and connected to the main earth system.

Unless specified otherwise, metal wastes of all baths and showers shall be bonded to the hot and cold-water pipes, as shall all sinks and basins within the building. Supplementary protective bonding shall be provided in accordance with BS 7671. The cables shall be run so as to be as inconspicuous as possible.

Provide bonding to all metal enclosures that surround electrical plant in accordance with BS 7671 and BS 7430.

2.6 Earth Electrodes

Unless specified otherwise the earth electrode system shall consist of rods. As an alternative use a tape or plate type of electrode but the Contractor shall be responsible for the design of the alternative method.

All earth electrodes shall be solid drawn 15 mm high conductivity copper rods. All earth rods shall be of proprietary manufacture and shall comprise 1.2 m long sections complete with internal screwed joints.

Provide a minimum of 2 No earth electrodes spaced at least 4 m apart. The cap of the earth electrodes and the tip shall be fitted with hardened steel components prior to driving.

Earth rods shall be interconnected and connected to the main earth bar via main bonding conductors as previously described. The final connection to the rods shall be by a proprietary clamp of heavy duty, purpose made aluminium bronze, or phosphor bronze and high tensile bolts. The connection shall be contained within a proprietary concrete inspection pit suitably labelled on the top of the cover.

The inspection pit shall be installed so that the top of the removable inspection cover is flush with the finished ground level. Ensure the enclosure provides adequate access for testing purposes.

Where electrodes need to be installed within buildings check they will not breach membranes intended to exclude water or penetrate any buried services. If it is necessary to breach damp-proof course membranes or tanking agree with the main contractor a method of sealing the breach.

Inscribe the cover of each pit with 'Electrical Earth Electrode' or 'Lightning Protection Earth' as appropriate.

The final connection to the rods shall be encapsulated in a non-setting compound that will not chemically react with the termination or retain moisture. Where the main bonding conductors are run in open ground, they shall be buried to a minimum depth of 450 mm and protected by a suitable non-conductive duct.

A PVC warning tape indicating the presence of a buried cable shall be laid in the ground 100 mm above the duct.

Where separate electrode systems are required they shall be installed at a sufficient distance apart below ground to prevent fortuitous earth paths in accordance with BS 7671, BS 7430 and BS EN 50522 as appropriate to the purpose of the earth electrode system, and prevent simultaneous contact above ground.

Where applicable, low voltage distribution systems shall only accommodate a single earthing system of one or more earth electrodes in accordance with the current edition of the electricity supply regulations. Where this may be inappropriate then the engineer's consent shall be sought prior to the introduction of any other electrodes to the LV system.

After installation of all earth electrode systems, tests shall be carried out in accordance with the respective British Standard to ensure that the appropriate earth electrode impedance does not exceed the permitted value within the relevant standards.

2.7 High Integrity Earthing

Provide high integrity earthing in accordance with the current edition of BS 7671 for final circuits that are designated to serve:

- Information and communications technology equipment
- Individual items of equipment or machinery that has protective conductor current exceeding 10 mA, or otherwise requires additional earthing as stated in the manufacturer's installation instructions
- Circuits where the total protective conductor current may exceed 10 mA
- All other circuits that incorporate a functional earth

2.8 Telecommunication Systems

Ensure the potential rise and induced voltages in telecommunications circuits due to power system earth faults is within the limits given in ITU-T K.68 for typical fault situations. Optical fibre communications cabling solutions shall be used to service hot sites. The Engineer's approval shall be sought for metallic ITC cabling crossing hot zone boundaries. Where approval is given, all of the mitigation measures of BS EN 50174-3 for hot zone entrance facilities shall be applied, including the provision of galvanic isolation and surge protection devices installed at both the service connection closure, and for equipment within the hot site.

Provide functional earthing in accordance with BS 6701 and BS EN 50310.

All cables that are solely used for functional earthing or functional bonding purposes only shall be pink and continuously marked 'TELECOMMS FUNCTIONAL EARTH' along its length according to BS 6701. A Traffolyte warning label complying with BS ISO 3864 and BS EN IEC/IEEE 82079-1 reading 'TELECOMMS EARTH DO NOT REMOVE' in engraved upper case characters not less than 5 mm high shall be permanently fixed at the points of connection in accordance with BS 6701.

Cables that combine protective and functional earthing shall be bi-coloured green-and-yellow and shall be installed in accordance with BS 6701 and BS 7671. In cases where BS 7671 does not mandate a label stating 'SAFETY ELECTRICAL CONNECTION DO NOT REMOVE', a Traffolyte warning label complying with BS ISO 3864 and BS EN IEC/IEEE 82079-1 reading 'SAFETY/TELECOMMS EARTH DO NOT REMOVE' in engraved upper case characters not less than 5 mm high shall be permanently fixed at the points of connection in accordance with BS 6701.

Where appropriate separate functional earth bars shall be provided within each power distribution unit for telecommunications equipment rooms. These functional earth bars shall be connected directly to the building main functional earthing terminal. The DC resistance of the functional earthing and bonding system, and the protective earthing and bonding system used for functional purposes, shall comply with BS EN 50310.

2.9 Generators

Provide earthing for generators, and other forms of generation, for example embedded generators, electrical energy storage systems, and combined heat and power, operating as a switched alternative to the distribution network supply in accordance with BS 7671 and BS 7430, and any requirements imposed by the distribution network operator.

Provide earthing arrangements for generators, and other forms of generation, for example embedded generators, electrical energy storage systems, and combined heat and power, operating in parallel with the distribution network supply in accordance with BS 7671 and BS 7430 and ENA Engineering Recommendations G98 or G99 as appropriate.

2.10 Mobile Generators

Provide appropriate earthing for mobile low voltage generators according to BS 7671, BS 7430, and BS 7909 as relevant. Provide earth electrodes for mobile generators where necessary. Earth electrodes shall be provided for systems powered by mobile generators where more than one item of equipment is supplied by the generator.

2.11 High Voltage System Earthing

The bonding of a high voltage system to a low voltage system shall only be permitted when the conditions described in BS EN 50522, BS EN 61936-1, and BS 7671 are met.

Where a HV earth electrode system is required install the system in accordance with BS EN 50522, BS EN 61936-1 and for earthing of substation/transformer installations, ENA Technical Specification 41-24. Connect all exposed-conductive-parts of the system to earth via protective conductors.

The two electrode systems shall be tested to verify that earth zones do not overlap and that no fortuitous loop paths are evident.

Provide earthing and bonding cables to achieve a low earth fault loop impedance path to operate earth fault relays as specified. Ensure extraneous-conductive-parts of the system are in direct contact with all simultaneously accessible exposed-conductive-parts and extraneous-conductive-parts, if necessary, by bonding or connection to the common steelwork structure.

Earth the HV system at one point only. Use the generator or supply transformer star point as indicated.

2.12 Earthing of Lighting Columns and Electrically Supplied Street Furniture

Install an earthing provision to street furniture in accordance with BS 7430 BS 7671 and ENA Engineering Recommendation G12/4.

For a TN-S supply system earthing arrangement use cable with to supply street furniture. Ensure on the load side of the protective device separate phase, neutral and protective conductors are used.

Connect exposed-conductive-parts of the street furniture to the earthing terminal within the equipment. Provide protective equipotential bonding in accordance with BS 7671, BS 7430, and ENA Engineering Recommendation G12/4. Connect the supply protective conductor to the same earthing terminal.

For a TN-C-S supply system, use a combined neutral and earth (CNE) cable on the supply side to supply street furniture. Use separate conductors for phase, neutral and protection on the load side of the protective device. Bond exposed-conductive-parts of the street furniture using a conductor sized in accordance with BS 7671, with minimum cross-sectional area of 6 mm².

Do not bond small items that are unlikely to come into contact with exposed- or extraneous-conductive-parts, or Earth. On circuits feeding more than one item of street furniture, provide an earth electrode of 20 Ohms or less resistance at the last or penultimate item of furniture on the circuit. Where an electrode resistance of 20 Ohms cannot be achieved, provide earth electrodes at each item of furniture.

For a TT earthing arrangement, or PME or PNB supply system earthing arrangements where the supplier's earth terminal is not used, install a protective earth electrode system at the source of supply. Use cable with separate phase, neutral and protective conductors to supply the street furniture, with the protective conductor connected to the earth electrode. Ensure on the load side of the protective device separate phase, neutral and protective conductors are used. Bond conductive parts of the street furniture to the earthing terminal within the equipment. Connect the supply protective conductor to the same earthing terminal. Fit earth bond fly leads of appropriate length to lighting column cut-out access panels.

2.13 Earthing of Electrical Systems in Hazardous Areas:

Install earthing of electrical systems in hazardous areas to BS 7430 and BS EN 60079-14. Use the recommendations in the APEA/EI publication Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4th Edition ('Blue Book') at petrol filling stations.

2.14 TT Supply

Ensure that conductors between the Regional Electric Company's equipment and main consumers main RCD are not contained within a steel enclosure or enclosed or formed by a cable that accommodates a steel sheath, unless protected by double or reinforced insulation.

3.0 Lightning Protection

3.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6701	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance. Specification for installation, operation and maintenance
BS 7430	Code of practice for protective earthing of electrical installations
BS 7671	Requirements for electrical installations
BS EN 1011-4	Welding. Recommendations for welding of metallic materials. Part 4 – Arc welding of aluminium and aluminium alloys.
BS EN 62305-1	Code of Practice for Protection of Structure against lightning. General principles
BS EN 62305-2	Protection against lightning. Risk management
BS EN 62305-3	Protection against lightning. Physical damage to structures and life hazard
BS EN 62305-4	Protection against lightning. Electrical and electronic systems within structures
BS EN 62561-1	Lightning protection system components (LPSC). Requirements for connection components
BS EN 62561-3	Lightning protection system components (LPSC). Requirements for isolating spark gaps (ISG)
BS EN 62561-4	Lightning protection system components (LPSC). Requirements for conductor fasteners
BS EN 62561-5	Lightning protection system components (LPSC). Requirements for earth electrode inspection housings and earth electrode seals
BS EN IEC 62561-2	Lightning Protection System Components (LPSC). Requirements for conductors and earth electrodes
BS EN IEC 62561-6	Lightning protection system components (LPSC). Requirements for lightning strike counters (LSC)
BS EN IEC 62561-7	Lightning protection system components (LPSC). Requirements for earthing enhancing compounds
DD CLC/TS 61643-12	Low-voltage surge protective devices. Surge protective devices connected to low-voltage power distribution systems. Selection and application principles
PD CLC/TS 61643-22	Low-voltage surge protective devices. Surge protective devices connected to telecommunications and signalling networks. Selection and application principles
PD IEC/TS 62561-8	Lightning protection system components (LPSC). Requirements for components for isolated LPS

3.2 General

Provide a lightning protection system in accordance with the above standards and codes to protect the building structure and personnel from the risk of a lightning strike.

Where necessary, engage a specialist to undertake the design, installation, testing and commissioning of the lightning protection system.

Where building and structural elements are to be used as part of the lightning protection system, or are to be bonded to the lightning protection system check they have been designed and erected in accordance with the relevant parts of BS EN 62305 and BS EN 62561/BS EN IEC 62561 (and for isolated LPS, PD IEC/TS 62561-8).

All connections made to the building and structural elements shall be waterproof and protected against corrosion with regard to the environment being served.

Seek and obtain all public utility company permissions and approvals for the installation of the lightning protection system. Fully comply with the respective utility company's regulations and requirements for the installation and connection of the lightning protection system.

Provide protection for the electrical installation and electronic systems in the building(s) in accordance with BS EN62305-4, BS 7671 and BS 6701.

Where connections are to be made to an existing system the soil resistivity and continuity of the existing system shall be tested in accordance with the relevant parts of BS EN 62305 and BS 7430.

For new and existing systems, the soil resistivity and earth electrode resistance shall be measured in accordance with the relevant parts of BS EN 62305 and BS 7430 – the method adopted shall be confirmed to the engineer prior to the test being carried out.

All defects and restrictions shall be reported to the engineer before connecting new or modified installations.

3.3 Air Terminations and Down Conductors

Air terminations shall conform to BS EN IEC 62561-2 (and PD IE/TS 62561-8 for isolated LPS), be formed and be of the type shown on the drawings.

Down conductors shall conform to BS EN IEC 62561-2 (and PD IE/TS 62561-8 for isolated LPS) and be constructed, formed, and located as detailed on the drawings.

Use of the building structure is permitted provided the material being used is of sound construction and has effective continuity in accordance with the relevant parts of BS EN 62305. Joints between various conductors of dissimilar metals and all bonding points shall be made using non-ferrous proprietary terminations conforming to BS EN 62561-1 (and PD IE/TS 62561-8 for isolated LPS).

Where the roof structure is unable to provide the function of the air terminal then decorative finials shall be used as shown on the drawings. They shall be proprietary manufactured of solid copper with cast gun-metal terminal base. The penetration through the structure and building fabric shall be made weatherproof upon completion.

3.4 Structures with metal roof(s)

The metal covering of the roof is to form the air termination component of the system. At each down conductor position install an accessible bolted connection to the metal roof covering, ensuring that it does not adversely affect the waterproof integrity of the roof. Ensure the metal roof covering forms a complete electrical network. Where any part of the metal roof is separate from the main roof ensure that they are electrically bonded together.

On completion of the metal roof covering test the continuity of the covering between the down conductor connection positions. Connect, by a bonding conductor, any part of the roof found to be electrically isolated from the remainder of the roof.

Ensure that the following minimum dimensions for metal roof covering to act as the air termination component, exist:

- galvanized steel 0.5 mm
- copper 0.3 mm
- aluminium 0.7 mm
- zinc 0.7 mm
- lead 2.0 mm

3.5 Structures with a flat roof(s)

Provide air termination by a conductor mesh having a grid of maximum dimensions 20 m × 10 m consisting of exposed copper or aluminium flat 25 mm × 3 mm tape fixed to the flat roof using manufacturer's proprietary fixings suited to the roof surface material. Bond the air termination grid to every down conductor.

Provide lightning protection to parapets using an exposed copper or aluminium flat 25 mm × 3 mm perimeter conduction tape, bonded to the grid and secured using manufacturer's proprietary fixings suited to the parapet surface material.

3.6 Structures with pitched roof(s) of tile or slate

Install vertical finials a minimum of 300 mm high at both ends of every ridge and at 20m intervals along every ridge. Interconnect them by a flat conductor tape installed along the ridge. Individually connect every vertical finial to the down conductor network by conductor tape installed under the roof tiles and fixed to the rafters using manufacturer's proprietary fixings.

Obtain agreement of the Architect to the finials (whether multi-point, purpose made, decorative, etc.) at the time of submission of working drawings.

(If it is not possible to install the tapes under the tiles they can be installed on the tiles and secured using manufacturer's proprietary holdfast fixings suited to the ridge tile and roof tile type and material. BS EN 62305 gives preference to exposed tapes, but they may be regarded as unsightly and are exposed to weather damage and corrosion. Where tapes are installed externally, finials may be unnecessary. Engineer to consider the need for eaves tape).

3.7 Tall structures

(The air termination at roof level should follow the detail, as appropriate, outlined above.)

For structures greater than 20 m in height extend the roof mounted air termination network to the upper vertical regions of the building using manufacturer's proprietary fixings suited to the wall surface material. (Alternatively, this may be inherently achieved by the steel structure or reinforcement of the building.).

(For tall buildings or structures with complex roof geometry) Use the rolling sphere method to determine the required locations for air terminations.

3.8 Down Conductor Paths

Ensure that all down conductors take the most direct route, without bends and without 're-entrant loops', from the air termination network to the earth termination network and have the minimum number of joints.

Arrange that there are no joints between the test joint and the connection to the electrode, in any down conductor.

Protect the down conductors from ground level corrosion by a PVC sleeve for a distance of 300 mm above and below ground.

3.9 Steel Framed Structures

Ensure that the position of structural steel columns that are utilised as down conductors, are no more than 20m apart around the perimeter at roof or ground level for buildings less than 20 m high, and no more than 10 m apart at roof or ground level for buildings 20 m high or more.

Install all bolted bonds, tapes and joints between the steel structure and the air termination network and between the steel structure and the earth termination network.

3.10 Reinforced and Pre-cast Concrete Structures

Use the metal bars within reinforced in-situ or pre-cast concrete structures as down conductors.

Ensure that the individual elements of the reinforcement are adequately bonded together by welding or wire binding, to ensure electrical continuity and low electrical resistance.

Supply all connectors used as joints between elements of reinforcement, as joints to the air termination network, and as joints to the earth termination network. Ensure all connecting components comply with BS EN 62561-1.

3.11 Non-steel Framed Structures

Where it is not possible to utilise the steel structure of the building as the down conductor path, install and fix conduction tape with down conductors positioned at no more than 20m apart around the perimeter at roof or ground level for buildings less than 20 m high, and no more than 10m apart at roof or ground level for buildings 20 m high or more.

Ensure that all down conductor tapes are flat 25 mm × 3 mm aluminium or copper fixed to the wall at no more than 1 m intervals using manufacturer's proprietary fixings suited to the wall surface material, and have a 3 mm minimum thickness anti-staining PVC sheath of a colour agreed by the Architect.

Install manufacturer's proprietary joints to the air termination network.

Where the down conductor tapes are aluminium install manufacturer's proprietary bi-metallic joints to the copper earth termination network. Do not bury aluminium tapes underground.

3.12 Connectors, Clamps, Links, Bonds and Bolts

Ensure that all connectors, clamps and links between tapes, all clamps of tapes onto structural reinforcing steel and structural steelwork, and all bonds of tapes onto components that are not part of the lightning protection system, are effective in reliably maintaining electrical continuity with negligible electrical resistance, and comply with BS EN 62561-1 or BS EN IEC 62561-2.

Clean all surfaces of conductors and apply a moisture inhibiting paste before jointing, and fit a proprietary waterproof shroud, colour matched to the PVC coloured conductor.

Robustly secure and fix all connectors, clamps, links and bonds so that the system is not damaged in operation.

3.13 Utilisation of Structural Reinforcing Bars

Where the structure of a building utilises reinforcing bars within its foundations, they may be used to provide ground terminations. Ensure there is full continuity between bars before using this method. Take precautions to ensure full continuity between the earth reinforcing bars and the lightning protection connections above ground.

3.14 Deep Driven Earth Electrodes

Where soil survey of the site indicates a low resistivity at greater depths Deep Driven Electrodes are the most suitable choice. Install within proprietary concrete inspection pits with lockable covers.

3.15 Parallel Earth Rod Electrodes

If ground conditions make deep driving of earth rods impossible, install a matrix arrangement of rods coupled to one other by 'ring-earth' interconnecting conductors, capable of being disconnected by test links from all earth rod electrodes.

Arrange all earth rods so that they are spaced apart by a distance at least equal to their driven depth.

Bury the 'ring-earth' conductor at least 600 mm below finished ground level.

3.16 Radial Strip Electrodes

If ground conditions are such that there is 1 m or less of topsoil above the bedrock, install a buried radial electrode. Bury an electrically continuous conductor at least 600 mm below finished ground level.

3.17 Test Joints

Connect every earth electrode to its corresponding down conductor with a test joint incorporated into its down conductor path.

Ensure that every test joint is a mechanically strong clamp complying with BS EN 62561-1 made from corrosion resistant metal with low electrical resistance.

At every deep driven earth electrode install an earth electrode inspection pit incorporating a test chamber complete with test clamp for bonding.

Ensure that, where test chambers are installed, they take the form of ground recessed inspection pits. Where inspection pits are installed within hard-core areas ensure the chambers are concrete. Where inspection pits are installed in the soft ensure they are made of a durable plastic.

3.18 Surge Protection Devices

3.18.1 Surge protection devices for the low voltage circuits and wiring

Ensure that every surge protection device is selected, installed and complies with DD CLC/TS 61643-12, BS EN 62305-4 and BS 7671; is suited for the location; is suited for the application; operates with 'line to

earth', 'line to neutral', 'neutral to earth', or 'line to line' mode of protection according to the application and has a suitable means of protection against overcurrent.

Ensure that every surge protection device is fitted with a means for signalling a voltage surge event to the BMS.

3.18.2 Surge protection devices for ICT cabling

Ensure that every surge protection device is selected, installed and complies with PD CLC/TS 61643-22, BS EN 62305-4 and BS 6701; is suited for the location; is suited for the application; operates with 'line to earth' or 'line to line' mode of protection according to the application.

3.19 Conductor Joints

Joints in circular conductors shall be made using proprietary clamp type couplings installed in accordance with the manufacturer's recommendations and soldered, brazed or welded as described below.

Joints in flat tape type conductors shall be made by tinning the joint faces with solder and securing the conductors to each other by a minimum of two copper rivets or two brass bolts. The joints shall then be sweat soldered or brazed at 600°C with zinc-free brazing or cold pressure welded.

Aluminium tapes shall use welded joints in accordance with BS EN 1011-4.

The joint faces shall be made to overlap.

Stranded conductors shall be LSZH sheathed and the joints made by compression type joints.

3.20 Bonding of Lightning Protection System

Connections to and from the conductors shall be made by stranded conductors by use of a crimped lug type connection applied by an automatic compression tool in accordance with the manufacturer's recommendations.

The lug connection shall be secured to the conductor and equipment by the means of phosphor bronze bolts, nuts and washers.

3.21 Labelling

Provide and fix system labels as required by the relevant parts of BS EN 62305 and BS 7671 and as described in elsewhere this document.

3.22 Operating & Maintenance Records

The operating and Maintenance manuals shall be complete with system records to the relevant parts of BS EN 62305 that includes the following items as a minimum;

- As installed drawings
- Nature of soil
- Earth resistivity measurement.
- Earth electrode resistance.
- Details of earth electrode types and locations

4.0 Transformers

4.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 50588-2	Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV. Transformers with cable boxes on the high-voltage and/or low-voltage side. General requirements for transformers with rated power less than or equal to 3 150 kVA
BS EN 50588-3	Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV. Transformers with cable boxes on the high-voltage and/or low-voltage side. Cable boxes type 1 for use on transformers meeting the requirements of EN 50588-2
BS EN 50588-4	Medium power transformers 50 Hz, with highest voltage for equipment not exceeding 36 kV. Transformers with cable boxes on the high-voltage and/or low-voltage side. Cable boxes type 2 for use on transformers meeting the requirements of EN 50588-2
BS EN 50708-1-1	Power transformers. Additional European requirements. Common part. General requirements
BS EN 50708-2-1	Power transformers. Additional European requirements. Medium power transformer. General requirements
BS EN 60076-series / BS EN IEC 60076-series / BS IEC 60076-series BS EN IEC 60076-11	Power Transformers
BS EN 60529	Specification for degrees of protection provided by enclosures
Commission regulation (EU) No 548/2014	Commission regulation implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to small, medium and large power transformers.
EU Directive 2009/125/EC	Establishing a framework for the setting of ecodesign requirements for energy-related products

4.2 General

Provide the specified transformers in accordance with relevant parts of BS EN 60076, BS EN IEC 60076, BS IEC 60076 and BS EN 50588 (where applicable), unless detailed otherwise.

Transformers shall comply with EU Regulation No 548/2014 implementing the Ecodesign Directive 2009/125/EC. The maximum-load losses and no-load losses for liquid-filled and cast resin transformers shall meet EU Regulation 548/2014 Tier 2 (2021).

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Where existing transformers are to be replaced arrange to carry out a test on the system to determine a suitable tap setting for the replacement transformer.

Distribution transformers shall be suitable for ground mounting as indicated on the drawings.

Provide off-load tapings on the high voltage winding for a variation of $\pm 2.5\%$ and $\pm 5\%$ of the primary voltage.

The terminals for the cabling on the secondary side shall afford the capacity to install a neutral conductor that is at least the same number of strands and cross-sectional area as the cables that serve the phase conductors. Where the transformer is to be close coupled to a circuit breaker, the throat and associated bus bars shall accommodate a neutral bus bar of equal size to the phase bus bars. At no time will reduced neutral conductors be permitted.

Unless specified otherwise, the neutral connection shall be made to a dedicated terminal in the LV cable box.

The distribution cable boxes shall be suitable for the number and size of conductors that they are designated to serve, as detailed on the drawings.

The exterior of each cable box shall be labelled with coloured button markers to denote the phase rotation when facing each respective cable box.

4.3 Oil or Synthetic Liquid Immersed Transformer

The transformer filling medium shall be either mineral oil or Midel 7131 as detailed within the design documents.

Tap changing shall be achieved by a control tapping switch that is an externally operated hand wheel which can be locked in any of the tap positions and fitted with a tap position indicator.

The tank shall be suitable to contain the oil or synthetic liquid used to insulate the transformer and shall be manufactured from welded mild steel.

The transformer tank shall be a free breathing type with gasket sealed joints or a welded sealed type as detailed within the design documents.

The tank shall be complete with, but not limited to, the following fittings as well as other ancillary items detailed within the design documents:

- Lifting lugs
- Tank earthing terminal
- Drain Valve and Plug
- Filling Plug
- Rating and connection plate

4.4 Cast Resin or Dry Type Transformers

Tap changing shall be achieved off-load by a set of bolted links to allow taps to be altered. The bolted links are to be proprietary manufactured by the transformer supplier.

The transformer winding construction shall comprise homogeneous, under vacuum, quartz-filled cast resin units. Their internal winding electrical stressing shall be minimised by the provision of sub-coils of spaced rounded wire which shall be wound integrally to avoid multiple braising of conductors and sharp edges. The

internal windings of transformers shall form a composite matrix with resin, each supporting each other. The coils shall be cured at the transformer's full operational temperature so as to relieve electro-mechanical stresses when the transformer is under full load conditions.

Transformer windings shall be fitted with two stage internal temperature sensors / thermistors, volt free contacts and terminals to provide a signal to start a forced draught fan followed by overheat condition audible and visual alarm indication, together with terminals to facilitate the shunt trip operation of the transformers primary side protection circuit breaker, as indicated on the attached drawings.

Dry type transformers to BS EN IEC 60076-11, BS EN 50708-1-1 or BS EN 50708-2-1 shall have a fire safety class of Class F1 unless stated otherwise.

4.5 Transformer Enclosure

Transformers shall be contained within a suitably ventilated enclosure with a canopy provided over the top section of the ventilation area. Access to the transformer shall be gained via front access doors. These doors shall be provided with electro-mechanical safety interlocks and door tamper micro switches to prevent unauthorised opening and tampering, as indicated on the drawings.

The enclosure shall be purpose fabricated and be specific to the respective transformer, constructed of a sheet steel case with lift off or hinged access panels. The minimum BS EN 60529 ingress protection rating shall be IP31.

The enclosure finish and supporting metalwork shall be high standard; metalwork shall be degreased with all rust removed prior to applying the paint finish. Compliance with the paint manufacturer's recommendations regarding preparation, stoving times, temperatures, mixing of finishes, application and coat thickness shall be carried out at all times. Finish and colour as manufacturer's standard unless otherwise specified. When other than the manufacturer's standard finish is specified samples for each paint system and for each colour shall be provided.

The enclosure shall be complete with, but not limited to the following fittings as well as other ancillary items detailed within the design documents:

- Two earthing tags
- Rating and connection plate
- Lifting lugs and lifting eyes
- Bi-directional rollers
- Hinged double access doors
- Cooling fan

5.0 Rotary Generators

5.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
	The Electricity at Work Regulations (1989)
	The Control of Pollution (Oil Storage) (England) Regulations & Pollution Prevention Guidelines
	The Management of Health & Safety at Work Regulations (1999)
BS 2869	Specification for fuel oils for agriculture, domestic and industrial engines and boilers
BS EN ISO 7235	Acoustics - Laboratory measurement procedures for ducted silencers and air-terminal units - Insertion loss, flow noise and total pressure loss
BS 4999-103 & 141	General requirements for rotating electrical machines
BS 5000-11	Specification for rotating electrical machines of particular types or for particular applications. Small-power electric motors and generators
BS 5000-3	Specification for rotating electrical machines of particular types or for particular applications. Generators to be driven by reciprocating internal combustion engines. Requirements for resistance to vibration
BS 5266	Emergency lighting. Code of Practice for the emergency lighting of premises
BS 5839-1V	Fire detection and alarm systems for Buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises
BS 6472-1	Guide to evaluation of human exposure to vibration in buildings.
BS 7671 / BS 7671 - A1	Requirements for electrical installations
BS 799-5	Specification for oil burning equipment. Carbon steel oil storage tanks.
BS 9999	Fire safety in the design, management and use of buildings. Code of practice.
BS EN 12285-series	Workshop fabricated steel tanks
BS EN 12464-2	Light and lighting. Lighting of workplaces. Outdoor workplaces
BS EN 1838	Lighting applications. Emergency lighting.
BS EN 50172 / BS 5266-8	Emergency escape lighting systems
BS EN 50342-series	Lead Acid starter batteries
BS EN 60034 -5	Rotating electrical machines. Degrees of protection provided by the integral design of rotating electrical machines.
BS EN 60034-22	Rotating electrical machines – AC Generators for reciprocating internal combustion engine driven generating sets.
BS EN 60085	Electrical insulation. Thermal evaluation and designation.
BS EN 60529	Specification for degrees of protection provided by enclosures
BS EN 61000-series	Electromagnetic Compatibility (EMC)
BS EN 61347-2-13	Lamp control gear. Particular requirements for D.C. or A.C. supplied electronic control gear for LED modules
BS EN 61439-series	Low voltage switchgear & control gear assemblies.

STANDARD	TITLE
BS EN 61869-series / BS EN IEC 61869-series v / BS IEC 61869-series	Instrument transformers
BS EN 62271-200	High-voltage switchgear and controlgear. AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
BS EN 62305-series	Code of practice for protection of structures against lightning
BS EN IEC 62384	DC or AC supplied electronic controlgear for LED modules. Performance requirements
BS EN ISO 12100	Safety of machinery. General principles for design. Risk assessments and risk reduction.
BS ISO 15550	Internal combustion engines. Determination and method for the measurement of engine power. General requirements.
BS ISO 3046-series	Reciprocating internal combustion engines. Performance.
BS ISO 6826	Reciprocating internal combustion engines. Fire protection.
BS ISO 8528-series	Reciprocating internal combustion engine driven alternating current generating sets
Directive (EU) 2015/2193	Medium Combustion Plant Directive (MCPD)
EN 590	European Fuel Standard
ENA Engineering Recommendation G100/1	Technical requirements for customer export limiting schemes
ENA Engineering Recommendation G5/5	Planning Levels for Harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the United Kingdom
ENA Engineering Recommendation G98/1	Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019
ENA Engineering Recommendation G99/1	Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
TR/20	Installation & testing of Oil pipework systems

5.2 Technical Project Documentation

The Contractor shall provide the following minimum documentation at timely points during the contract:

- Functional design specification for all aspects of the generator system (for approval)
- Control system performance and configuration specification to describe control strategy, maintenance strategy, software graphical diagrams (for approval)
- Generator Controller Panel (GCP) and output panel diagrams (for approval)
- Layout, section and schematic/drawings/graphics (for approval)
- Full details of the fuel transfer system including: Fuel pipework schematics, fuel transfer system calculations; technical submissions for the complete fuel system including components and materials; full details of the fuel transfer MCC including description of operations
- Full technical submissions for all generator system components including ancillary systems
- Full technical assessment of noise levels to be achieved at 1m from the inlet and outlet louvres, for a single generator set at 100% load duty. The effect of the engine exhaust shall also be considered. The assessment shall be made using recognized acoustic calculation techniques. Insertion loss data for attenuators shall be based upon certified test data, and evidence shall be submitted as part of the assessment. The assessment shall account for the noise level of any engine cooling fan, based upon certified fan noise level data
- Factory acceptance test procedures (for approval)

- Site acceptance test procedures (for approval)
- Standard Operating & maintenance procedures
- Client training notes

The system specification and the configuration specification must be approved prior to the beginning of the manufacturing phase.

Drawings, material submissions and safe systems of work in the form of method statements and risk assessments shall be provided for all aspects of the works prior to procurement of materials and commencement of site works.

5.3 General

Supply and install in accordance with manufacturer's recommendations a diesel generator set that fulfils the required parameters. Set the unit into position to facilitate on-site maintenance and repairs, including barring facility where indicated. Provide access for removal of pistons and connecting rods.

Provide a set of any special tools that are necessary to enable the client's maintenance staff to maintain the unit upon completion. The tools shall be contained within a lockable enclosure and comprise the necessary tools to allow full maintenance of the unit to be carried out in accordance with manufacturer's recommendations.

Unless specified otherwise the generating plant shall be compatible and capable of operating at the following environmental parameters:

- | | |
|----------------------------------|------------------|
| • Standard Reference Conditions: | BS ISO 8528 |
| • Height above sea level: | Less than 1000 m |
| • Max Ambient temperature: | 40°C |
| • Relative humidity: | 60% |

The generated voltage and frequency shall be maintained at all times within limits appropriate to performance class and suppress radio interference in accordance with the relevant parts of BS EN 61000.

The generating set shall be capable of running up to normal speed and accepting full load in the time indicated within the design documents. If no time duration is specified, the minimum duration for full load acceptance shall be taken as 10 seconds.

Each specified generator shall be complete with guards to protect operatives and components from all exposed hot or moving parts in accordance with the Health and Safety at Work Act, 1974. Hot surfaces presenting a contact or combustion hazard shall be guarded or insulated with 50 mm thick mineral wool mattress to density 90 kg/m³ and suitable for a temperature of 950°C. The mineral wool shall be encased in hammer clad aluminium overall.

Suitable warning notices shall be displayed on guards.

The installation, including air intakes, air discharges and exhaust shall limit noise emission from the generator room/enclosure to not greater than 70dBA at one metre or as otherwise scheduled.

5.4 Performance Criterion

Provide a generator set that complies with BS ISO 8528 and comprises a diesel engine, direct driven alternator/exciter, cooling system, exhaust system, engine/alternator control panel, a daily service fuel oil tank and engine starting system.

The generator set shall be installed and configured as scheduled within the design documents. Anti-vibration mounts shall be provided between the base frame and the enclosure floor to eliminate structure borne noise or vibration.

Consideration shall be given to the vibration and noise criteria when the generator is on part load as well as full load.

For all values of active power up to the prime rating of the generating set, it shall be capable of accepting a load with a leading power factor up to 0.3 p.u. of the rated prime apparent power of the set across the range of operating voltage of the set.

The rated apparent power of the alternator shall be suitable for load with a lagging power factor (cos phi) of 0.8 up to the nett prime rated power of the prime mover.

5.5 Generator Enclosure

Where scheduled, supply a weatherproof, acoustic enclosure constructed from mild steel incorporating air inlet attenuators.

The enclosure shall be provided with the following facilities:

- Heating that shall maintain a temperature of 10°C with an outside temperature of minus 4.5 C.
- Lighting to an illumination level of 150 lux at the floor level of the enclosure
- An illumination level of 300 lux to the front and rear panels
- Emergency lighting
- Flame/Heat detectors in accordance with BS 5839-1
- Break glass alarm unit and strobe alarm

The enclosure shall provide sufficient air flow to cool the alternator and engine at all times.

The enclosure finish shall be the manufacturer's standard unless otherwise detailed within the design documents.

5.6 Diesel Engine

The engine performance shall be in accordance with BS ISO 8528, the engine type shall be four stroke and may be either, air cooled / water cooled, turbo-charged or normally aspirated to suit duty as scheduled. The fuel oil shall be Class A2 in accordance with BS 2869.

The generator shall be provided with an engine speed governing system in accordance with BS ISO 3046.

Provide suitable controls to manually adjust speed of engine + or - 5% from nominal speed under all load conditions.

An engine over speed protection device shall be provided as part of the system in accordance with BS ISO 3046, and shall be incorporated into the speed control system.

The torsional vibrations shall comply with BS ISO 3046.

5.6.1 General Description

The engine shall:

- Be full compression ignition type with a nominal crankshaft speed of 1500rpm

- Operate on commercial grades of diesel fuel
- Incorporate replaceable element dry vortex type air cleaners with service indication, minimum efficiency 99.8%
- Be suitable for a minimum stack back pressure of 5kPa but demonstrate silence
- Each engine alternator shall be mounted on a heavy-duty base frame in accordance with the engine and alternators manufacturers recommendations for tolerances and vibration

5.6.2 Engine Power Rating

The rated net horsepower of the engine at the generator synchronous speed, with all accessories, shall not be less than that required to produce the kW load. The horsepower rating shall take into account generator efficiency and all parasitic losses such as fans, heaters, battery charger, etc. The generator set shall be capable of producing the specified kW (without overload) for the duration of the power outage, under the following ambient conditions:

Altitude: up to and including 1000 m

Maximum air temperature at engine intake 40°C

Humidity Range: 0 - 100%

5.6.3 Governor (Engine Speed Control)

The engine shall be equipped with a suitable governor to maintain frequency within limits, as specified by the operational class in accordance with ISO 8528, by controlling engine and generator speed.

Manual speed adjusting control shall be mechanical or electrical if located on the generator set or electrical if located in a remote control panel.

The generator voltage regulator shall be equipped with reactive droop compensation or reactive differential compensation.

The voltage regulator shall be provided with an excitation support system which shall ensure:

- I. The supply of a minimum of 2.5 x rated full load current (into a balanced 3-phase fault), to allow selective operation of protection equipment
- II. The supply of motor start-up and other inrush current demands. For design and test purposes, the motor starting current shall be assumed to be equal to 2.7 x (rated kVA of generator). The generator winding shall be protected against damage caused by current allowed to flow by operation of the excitation support system.

The voltage regulator shall be suitable for use with a generator output in which the current has a THD of 15% (as produced by 3-phase rectifiers of motor VSD inverters).

5.7 Water Cooling System

Any generator to be provided shall incorporate a cooling system that cools the engine when running on continuous full load and on 10% overload for one hour in accordance with BS ISO 3046.

Unless otherwise detailed, the radiator shall be an air blast type, complete with integral header, separate sections shall be provided, where appropriate for the water and lubricating oil systems. Where ducted discharge is required from the radiator a proprietary flange shall be provided with the generator. The radiator shall be set mounted with engine driven fan upstream of radiator, or remote with motor driven fan upstream of radiator where appropriate.

The generator unit shall be provided with an engine driven pump to circulate jacket water through radiator. The lubricating oil shall be circulated through a radiator (where appropriate).

The generator shall be provided with a thermostatically controlled diverting valve in the engine cooling water discharge pipe work with by-pass to circulating pump suction.

The water-cooling system shall be complete with drain points at low points in engine cooling water system.

A mixture of water and antifreeze shall be applied to the engine cooling water system. The mixture shall be the concentration stipulated by the manufacturer.

A 230 V single phase, thermostatically controlled immersion heater shall be provided within the engine cooling water system. The electrical supply to the heater shall be derived from a non-maintained mains supply that is to be controlled by an isolating switch and is to be in close proximity to the engine/alternator control panel. The control shall be configured such that the heater is OFF when the engine is running.

A heater shall be provided for the lubricating oil system.

5.8 Air Cooling System

The generator shall be provided with engine driven fans to circulate the cooling air for the engine. Where ducted discharge is required a proprietary flange to terminate the generator to the ductwork shall achieve the connection to the ductwork.

The manufacturer shall design the cooling system to provide for effective cooling when the generator runs continuously at full load and on 10% overload for one hour in accordance with BS ISO 3046. The radiator core and fin design shall take into account compensation for possible ingress of dirt which would normally clog the fins.

5.9 Engine Lubrication

The engine shall be provided with a high capacity lube oil system comprising positive displacement pumps, adjustable regulators, and replaceable element filters to maintain full pressure regulation to the main bearing, con rods, camshaft bearings, turbo charger(s) valve and timing gear.

The system shall include an oil cooler, and be provided with suitable valves to allow draining of the system

The generator system shall afford automatic engine lubrication by the use of an integral gear driven pump. The pump shall facilitate a coarse strainer on the suction side and full flow filter on the delivery side.

The engine set-up shall ensure that the engine lubricating oil dipstick is accessible and marked to indicate maximum and minimum levels.

The generator shall be provided with an engine sump that incorporates an accessible drain point or drainpipe.

The generator shall be provided with an electric motor driven lubricating priming pump with automatic intermittent time control to keep engine bearings lubricated.

The generator shall provide for the lubricating oil system to enable the engine to run continuously for period detailed within the schedules, drawings or design documents at any load without replenishment. The system shall be capable of being replenished while the engine is running.

5.10 Engine Starting System

Supply and install a 24 V DC supply to start the engine from any crankshaft position, by axial type starter motor engaging with flywheel. Ensure that the starter motor disengages automatically when engine starts or when de-energised.

The starter motor shall be accessible and installed complete with non-conducting protective shrouds to all terminals.

The DC system shall be capable of a minimum of six crank cycles (rolling) of the specified prime mover (3 x 10 second alternating crank cycles per system) and have sufficient current available for "break-away" currents for the particular engine used at the specified worse case temperature and without charge.

5.11 Starter Batteries/Chargers

Provide batteries that have the capacity to crank the engine 6 times in succession when the engine is cold, 0°C, with 10 seconds between starts.

The batteries shall offer low maintenance, be sealed and be of the lead acid type to BS EN 50342. The connections shall be inter-cell with shielded output connections to prevent inadvertent contact. Shield/shrouds shall be impact resistant PVC.

The batteries shall be mounted on either open type acid resistant stands or in proprietary manufactured ventilated steel cubicles as detailed within the design documents.

Provide a battery charger as part of the installation. The charger shall be a current-limited constant-current/constant-voltage type in accordance with battery manufacturer's recommendations.

Provide a BS EN 60529 IP31 rated rigid steel free-standing floor-mounted enclosure to contain the charger.

The charger shall facilitate boost and trickle charging, include over current and over voltage protection, provide for earth fault detection and alarm where battery and charging system are not connected to the earthed system, provide battery on-load disconnection and fuses.

The battery charger shall accommodate the following monitoring instrumentation

- Incoming supply ON/OFF switch with illuminated LED
- Charge input and output cartridge fuses or circuit breakers
- Voltmeter to indicate battery/charging voltage
- Ammeter to indicate charge /discharge
- Battery charge output failure detector with volt free contacts to actuate a remote alarm

5.12 Exhaust system

Provide an exhaust system that is in accordance with manufacturer's recommendations and achieves the noise limitation requirements. The exhaust system shall comprise exhaust silencer, expansion bellows and all fittings, gaskets, joints and fixings recommended by the manufacturer.

The exhaust system including silencers shall be of such size that backpressure on the system will not exceed the backpressure permitted by the engine manufacturer's recommendation.

A flexible connection shall be mounted at the engine exhaust outlet and the discharge end of the exhaust line.

The exhaust discharge shall be protected against entry of precipitation and vermin.

Unless detailed otherwise, the manufacturer's standard material shall be utilised to form the exhaust system.

The exhaust system shall be mounted using proprietary suspension brackets that are in accordance with the manufacturer's recommendations and do not transmit vibration into the structure.

The exhaust system shall incorporate drain points in effective locations to remove any condensate. Thermally insulate the manifold and all exposed exhaust pipe runs.

The exhaust systems shall be of twin flue design to minimise heat rise and be suitably insulated to prevent overheating of the engine room/container and structure.

Upon completion of the erected exhaust system, carry out a pressure test for leakage prior to connection to engine.

5.12.1 Exhaust Emissions

Exhaust emissions shall be as per the engine manufacturer's standard for emissions optimised engines and to suit the requirements of the Industrial Emissions Directive.

5.13 Filtration System

Each engine shall be fitted with heavy-duty dry type air filters with replacement elements. The engine shall be complete with fuel and lubricating oil filters with replaceable elements.

5.13.1 Air Supply Cleaner

An air cleaner and silencer shall be furnished as recommended by the engine manufacturer and shall be located and mounted as recommended by the engine manufacturer.

5.14 Alternator/Exciter

5.14.1 Generator Description

The generator shall accommodate a brushless alternator with a directly coupled ac exciter that incorporates over-excitation protection on solid-state rectifiers. Where applicable, a damper winding shall be provided within the rotor to enable parallel configuration. The alternator/exciter shall comply with the relevant parts of BS 4999, BS 5000, BS ISO 8528 and BS EN 60034-22.

The alternators/excitors shall be flange or foot mounted to suit the specific set configuration. The connections shall be 'Star' configuration with 'ABC' phase rotation and a neutral connection brought out to the alternator terminal box from the star point of the windings.

The alternator shall be contained within a screened, an IP22 drip proof enclosure complying with BS EN 60034-5. The bearings shall be determined by the manufacturer unless otherwise detailed.

5.14.2 Rating

The alternator shall be capable of maintaining the following load criteria at an ambient temperature of 40°C.

- 110% of the generator continuous full load as defined in ISO 8528-1
- 150% full load for one minute
- 300% full load for 10 seconds

Class of insulation shall be in compliance with relevant British, CENELEC and IEC standards.

5.15 Automatic Voltage Regulator

The generator shall be provided with a solid-state type automatic voltage regulator that accommodates manual adjustment to set the alternator output voltage within the tolerance detailed within the schedules.

The regulator shall be mounted either on the set or within the control cubicle.

An enclosure shall be provided as part of the installation to contain regulator components that are isolated from the generator using anti-vibration mountings.

5.16 Engine / Alternator Instrument Panel

5.16.1 General

Provide as part of the generator installation the control gear and switchgear to support the function of the generator(s) in accordance with BS ISO 8528.

Unless defined otherwise, the facilities detailed below shall be provided as a minimum requirement.

- The control panel shall be either set mounted or floor standing
- The enclosure shall be fabricated from folded steel to IP31 in accordance with relevant parts of BS EN 61439
- A 230 V thermostatically controlled anti-condensation heater

All instruments, controls and indicating lights shall be properly identified. All wires shall be individually identified and must agree with wiring diagrams provided. Terminals on all terminal blocks shall be individually identified.

The panel shall be individually identified by a Traffolyte label identifying the generator reference as defined on the schematic and layout drawings.

5.16.2 Engine control section

- Key operated duty selector switch 3/4 position
- Manual engine start and stop push buttons
- Engine automatic start and stop control system with adjustable time delay start and shut down timers where appropriate
- Engine speed adjustment trimmer rheostat
- Engine hours run recorder

5.16.3 Engine fault protection

Provide engine fault protection, automatic shutdown and lock out of service devices to protect engine against effects of:

- Over speed
- Lubricating oil pressure low
- Cooling water temperature high
- Additional protection as scheduled

5.16.4 Instruments and Controls

The following engine and generator instruments and controls shall be furnished and installed either as individual units or provided via an electronic controller HMI:

- Engine speed RPM
- Ammeter
- Voltmeter
- Voltmeter/ammeter phase
- Wattmeter
- Voltage adjustment control
- Frequency Meter
- Governor speed adjusting control
- Water temperature gauge
- Oil Pressure gauge
- Manual start/stop control
- Engine runtime meter
- Indicator lights for engine alarms
- Paralleling and synchronisation controls (where applicable)
- Reverse power relay (where applicable)
- PF
- kVA
- kVAr
- Mains failure detection/protection:
 - Over / Under Voltage
 - Over / Under Frequency
 - Voltage Imbalance
 - Battery voltage indication

5.16.5 Engine Protective Devices

The following engine protective devices shall be provided, and indication shall be supplied for use with each device specified.

- Combination alarm and shutdown system for high water/oil temperature and/or low oil pressure
- Engine under/over-speed automatic shutdown device
- Engine under/over voltage
- Engine under/over frequency
- Engine failed to start indicator light (over crank)
- Alarm for low coolant level
- Engine overload (via alternator)
- Fail to synchronise
- Fire valve operated
- Reverse power
- Restricted Earth Fault operated
- Alternator excitation loss

In the event of a fire each generator shall incorporate a heat activated fuel supply isolation valve. On operation, this shall signal the respective generator control panel to shut down the engine. The generator shall not try to start if this valve is closed.

5.16.6 Protection

- Triple pole ACB/MCCB rated to suit the full load capacity of the generator, plus 10%, at unity power factor for instances where the distribution network earth electrode is common to the generator
- Four pole ACB/MCCB rated to suit the full load capacity of the generator, plus 10%, at unity power factor for instances where the generator has an independent earth electrode separate from the distribution network earth electrode

- Over current unit protection to protect the distribution feeder cables as well as the generator

5.17 Fuel System

5.17.1 Overview

The fuel system shall include fuel storage, fuel transfer systems, fill cabinet and daily service tanks in accordance with the project specific requirements.

5.17.2 Bulk Fuel Storage Tank

The bulk fuel storage tanks shall be manufactured in accordance with BS 799: Part 5: Type G.

Final finishes of the fuel tanks shall be project specific.

Tanks shall be fitted with the following: -

- Access man way cover containing high- and low-level alarm probes
- Hydrostatic contents gauge located within the fuel fill point
- Vent pipe
- Fill pipe connection
- Fuel lines take off
- Valved sludge suction drain point
- Access ladder and man safe system to provide maintenance access to the top of the tanks and associated fuel pipe connections, all suitable connected to earth, where applicable
- A high-level float switch which provides signal 'full' to the fill point cabinet alarm & remote alarm where applicable
- A low-level float switch which will close the motorised suction valve & remote alarm where applicable
- A low-level float switch which provides a remote alarm signal via the pump control system
- A tank bund alarm float switch which provides an alarm signal via the pump control systems
- Motorised suction valve
- Overfill prevention valve
- Fuel Polishing Unit where applicable

All tanks shall be new and unused, and no galvanized material shall be used in the tank or system. The tanks shall be furnished with a foot or check valve located in the supply pipe of the tank to ensure that fuel pump priming is maintained. The tank shall be vented to atmosphere and provided with a suction drainpipe to draw off any water forming at the base of the tank. The tank shall be provided with leak detection and earthing points accessible via the manway chamber.

5.17.3 Fuel Delivery System

Provide a complete fuel system; from the fill point cabinet there shall be an individual fully welded double skin pipe in pipe to the storage tank(s). Connection to the bulk tank(s) shall be via an overfill prevention valve. A suction line from the bulk tank(s) shall supply fuel to the system via a duplex pump set via a normally open motorised valve that is controlled via a lo-lo level float switch. On a lo-lo signal from this float switch the valve shall be motored closed to prevent drawing air into the system.

All pipe work shall be pipe in pipe construction from:

- Fuel delivery point to bulk fuel tanks
- Bulk fuel tanks to a tanked valve connection point for connection to fuel transfer pump manifolds
- From transfer pumps to the daily service tanks

Pipe sizes shall be no smaller than the minimum recommended by the engine manufacturer to avoid fuel flow restriction. The lift and capacity of the generator fuel delivery pumps shall ensure adequate delivery of fuel to the day tanks at a rate in excess of the maximum fuel rate of the engines.

Pipe lines shall be equipped with fuel filters, gate valves and fusible link fire safety systems that shall include a manual release button at each exit door from the engine room/container.

All pipe work shall be steel manufacture installed in accordance with HVCA TR/20 and environmental standards.

All pipe runs shall be laid to pitch and supported with proprietary fixing rings, clips and saddles to manufacturers recommendations.

Strainers and water separators shall be provided within the system to ensure fuel quality is maintained at the point of use. Valves shall be provided to enable each bulk fuel tank to be isolated from the fuel delivery system; additional valves shall be provided to enable each day tank and each item of plant to be isolated from the system.

All fuel lines shall be painted with brown gloss (C60) paint finish and then marked with liquid type and flow direction arrows.

5.17.4 Daily Fuel Tanks

Each diesel generator shall be equipped with a double-skinned daily fuel tank, which shall be mounted adjacent to or below the generator set. The tank shall be complete with

- Dial type contents gauge
- Overflow connection
- Filling connection
- Drain plug
- Outlet jettison connection
- Weight operated 3-way fire valve to close the fuel outlet to the engine and open the jettison outlet in the event of fire
- Injection spill and excess fuel return connection
- Bolted access cover
- Vent with gauze flame trap
- Additional fittings as scheduled

The tank shall be made of 2 mm thick sheet metal construction and be mounted on a floor-mounted frame. The tank shall be new and unused and shall not be galvanized.

Fuel level float switches shall be provided on 4 levels to control the electrical fuel pumps and for signalling purpose.

A low low-level alarm operated by a float switch shall be provided to give an audible and visual alarm on the control panel when the fuel level drops below a percentage of the total capacity.

A high high-level alarm operated by a float switch shall be provided to give an audible and visual alarm on the control panel when the fuel level exceeds a percentage of the total capacity.

Dual electrical pumps shall be provided to fill the daily fuel tank automatically from the bulk storage tanks. Additionally, a semi rotary hand pump, complete with the necessary gate and non-return valves, shall be provided.

Gravity shutdown fire valve operated by a fusible link shall be fitted to close off the main fuel supply to the set in the event of a fire on that set.

The tank shall be equipped with a suitable breather.

The tank shall be provided with a drain cock to allow the tank to be completely drained.

Fuel from the daily storage tanks shall typically be transferred to the engines by gravity.

Pipe sizes shall be no smaller than the minimum recommended by the engine manufacturer to avoid fuel flow restriction. The engine supply and return line shall be equipped with a length of flexible fuel lines, unions and gate valves. No copper lines are acceptable.

5.17.5 Fuel Fill Cabinet

A fuel fill point shall be provided adjacent to the bulk fuel tanks.

The fill point shall be a proprietary lockable cabinet including the following;

- Hygroscopic gauge for local display of contents
- Earth strap for tanker
- Overfill (smart) alarm with slam shut valve
- Drip tray at delivery point pipework connection

All items shall be marked with Traffolyte labels in accordance with the design.

5.17.6 Lightning Protection

To ensure the installation can adequately deal with the effects of a lightning strike each fuel tank shall be connected to the general mass of the building earth via copper tapes and therefore have suitable bolted earthing connections on the tanks, containment, pipework, access ways and all general metalwork.

5.17.7 Diesel Fuel Polishing

Unless otherwise specified the Contractor shall install a packaged diesel fuel polishing system for each bulk storage tank, system supplied by Wasp PFS or equal and approved by the Engineer.

The fuel polishing system shall clean the fuel to a level of 2 microns and remove free and emulsified water. The fuel condition shall eliminate the build-up of algae and water.

Each system shall be 230V AC power supplied capable for automatic or manual control as well as BMS Modbus interface for remote operation. Volt free alarm shall be provided for the following:

- Service filter alarm
- Water in fuel alarm
- Differential pressure alarm

5.18 Installation and Assembly

5.18.1 Assembly Drawings and Wiring Diagrams

Copies of installation drawings and complete wiring diagrams and interconnections shall be furnished to the engineer and furnished within the O&M manuals.

All wiring and interconnections shall be tested and installed in accordance with BS 7671/A1. Test certification shall be provided for the entire installation.

All LV cabling shall be installed on cable ladder or cable tray and fixed with proprietary fasteners suitable for the sheath.

All controls cabling shall be installed on cable basket containment and fixed with proprietary fasteners suitable for the sheath. Tie wraps on copper and fibre ICT cabling will not be acceptable.

5.18.2 Mounting

The mounting of the generator set shall be sufficiently rigid to maintain alignment and to minimize the engine and generator stresses. The floor loading shall not exceed the Structural Engineer's design. A suitable number of isolators shall be inserted between the engine generator set and its base. The engine height shall accommodate convenient draining of sump.

The generators shall be vibration isolated by means of suitable steel spring anti-vibration mountings having a static deflection of 40mm or rubber bonded anti-vibration mounts to give a maximum of 93% vibration isolation.

5.18.3 Ventilation Requirements

The supplier shall provide with their submittal confirmation of air flow requirements for cooling and combustion, plus the heat rejection of the engine and generator when operating at 100% load. These estimates shall be supported by manufacturer's data and shall allow thermal airflow modelling.

5.18.4 Torsional Vibrations

The system shall be free of injurious torsion and bending vibrations within a speed range from 10% below to 10% above synchronous speed.

5.18.5 Guards

The system shall be adequately guarded both physically and electrically for protection of operating personnel and where elements of the system pass through non plant areas; they shall be adequately guarded for protection of the general public.

5.18.6 Labelling

Warning Labels - A danger label shall be fixed to each removable busbar access cover. This label shall be as per the requirements of the specification, with 2 no. 3mm diameter-fixing holes.

All label edges shall be slightly chamfered.

Warning labels shall include the system voltage, i.e.: DANGER-11000V or 400V LIVE BUS BARS.

Where removable bus bar access covers have been removed and conductors still remain live after de-energising, a warning label shall be fitted, manufactured to the above specification, reading:

DANGER
11000 / 400V ISOLATE ELSEWHERE
BEFORE REMOVING THIS COVER

Warning labels shall be generally fixed as follows:

- Small Covers - Centre of panel or cover

- Full Height Covers - At eye level.

The generator manufacturer shall uniquely identify each item of plant with a Traffolyte label.

5.19 Acoustic Control

5.19.1 Acoustic Criteria

The specialist generator contractor shall provide all acoustic treatment as required to meet the acoustic criteria described herein including, incoming air inlet attenuation, discharge air attenuation, and engine exhaust silencers.

Where discharge attenuators and silencers sit in weather exposed location, they must comprise suitable materials to be maintenance free in use and prevent degradation of performance due to weather impact. Noise and vibration transfer to both internal and external areas shall not exceed the design criteria. These are to be achieved at maximum design load and any intermediate load. Appropriate allowances shall be made for noise from other generators and external plant.

5.19.2 Atmospheric Noise Emissions

Atmospheric noise emissions for each individual generator shall not exceed that stated in the particular specification at 1m from the inlet or outlet louvers, or the exhaust flue.

5.19.3 General

The contractor shall provide calculations for all materials and products to be used for the attenuation of the generator systems to meet the above criteria.

5.19.4 Data and Liaison Required

The contractor shall supply the following information:

- Expected octave band noise data for the generator sets
- The insertion losses expected from the silencers offered, under the operating conditions, with the data derived from tests carried out in accordance with BS EN 7235 (and all current amendments)
- The silencer pressure losses expected at the design flow and temperature derived from tests carried out in accordance with BS EN 7235 (and all current amendments) and the expected effect of turbulence due to adjacent duct elements on the quoted pressure losses
- Silencer generated octave band sound power levels (125 Hz to 8 kHz) at the operating conditions
- Expected octave band levels of atmospheric noise emissions from exhaust discharge and any externally located exhaust components

5.20 Container General Lighting

5.20.1 Performance Objectives

The objectives are to provide a reliable efficient lighting installation to meet the illumination levels specified.

5.20.2 Design Parameters

The artificial lighting installation shall be provided to achieve the requirements of:

- BS EN 12464 Light and Lighting (Lighting of Workplaces)
- CIBSE Code for Lighting and subsequent addendums/amendments

5.20.3 System Description

The Contractor shall Design, Supply, install connect and commission the complete lighting installation within the container of the new Generator.

Luminaires shall be installed in accordance with the manufacturer's instructions in particular with regard to environment and operating conditions (i.e. orientation of lamp/luminaire).

Lighting to plant rooms associated circulation corridors and within containerised plant shall be IP65 rated, surface mounted linear LED luminaires complete with clear polycarbonate diffuser and LED drivers. All lamps shall be high efficiency with a colour temperature of 4000K.

Final circuit wiring shall be carried out in single core cables enclosed within a metallic conduit/trunking system. Final connections to recessed luminaires shall be by a flexible cord and cable or luminaire support coupler arrangement.

Relevant drivers complying with BS EN 61347-2-13 and BS EN 62384 mounted on removable gear trays shall be used for all luminaires.

All drivers/control gear shall comply with the relevant Harmonized Standards (CE).

The overall power factor of luminaires shall not be less than 0.95 lagging.

All lamps with associated drivers shall have an MTBF of at least 30,000 hrs.

All lamps within an area shall be of the same type, characteristics and be supplied by the same manufacturer from a common batch. Noticeable colour difference will not be accepted.

All luminaries shall be connected to final radial circuits protected by a type C MCB of maximum rating 10 A having a short circuit current withstand rating suitable for the fault level at the relevant distribution board or switchboard but not less than 10 kA at 400 V AC. Refer to distribution board circuit chart for details.

5.20.4 Control Requirements

All switches shall be rated to suit the load current and characteristics.

All 230 V rated lighting switches shall be rated for a minimum inductive load of 20 A.

Local lighting shall be controlled by local switches which shall be surface metal-clad pattern galvanised finish.

5.21 Container Emergency Lighting

5.21.1 Performance Objectives

The performance objectives are to provide a system of lighting to enable safe movement of personnel in the event of mains or local circuit failure.

5.21.2 Design Parameters

The system shall be provided in accordance with the following:

- BS EN 1838
- BS EN 50172 (BS 5266-8) Emergency escape lighting systems
- CIBSE Lighting Guide 12: Emergency Lighting Design Guide
- BS 5266 Code of Practice for the Emergency Lighting of Premises

The system uniformity shall be better than 40:1 and shall utilise ICEL certified equipment.

5.21.3 System Description

The Contractor shall Design, Supply, install, connect and commission the complete emergency lighting system within the container of the Generator.

All emergency lighting shall be provided via integral battery units within the general lighting fittings.

All emergency lighting from the general lighting circuit serving that luminaire, via an un-switched live, shall be connected using a four-pin lighting coupler assembly deriving from the local lighting circuit wiring.

Facilities for testing emergency lighting equipment shall comprise switches located adjacent to the general lighting distribution board positions. The test switches shall control the "un-switched" feed to the luminaire and shall be labelled accordingly. A separate test switch shall be provided for each circuit supplying emergency luminaires.

The emergency lighting system shall operate for a minimum duration of 3 hours on failure of the associated sensing circuit, with a recovery rate not exceeding 12 hours.

The Contractor shall be totally responsible for ensuring that each un-switched live feed to each emergency luminaire is fed from the same final circuit in order to provide final circuit protection and is on the same phase as the normal supply. On no account shall 400 volts appear within the same luminaire.

Upon completion of the emergency lighting system the Contractor shall commission the entire system to the complete satisfaction of the Engineer. This shall include a record of all measured lighting levels and battery discharge times. The Contractor shall issue all necessary certificates/approval documentation/results print-outs, as required.

5.22 Container Fire Detection & Alarm System

5.22.1 Performance Objectives

Fire detection and suppression (where required) shall be provided within the container for interfacing with the in-house fire detection and alarm systems in accordance with BS 9999 and BS 5839-1.

5.23 Quality and Experience

All materials and parts of the generator set shall be OEM, new and unused. Each component shall be of current manufacture from a firm regularly engaged in the production of such equipment. Units and components offered under these specifications shall be covered by the manufacturer's standard warranty on new machines, a copy of which shall be included in the submittal.

5.24 Parts and Service

Bids shall be accepted only on engine driven generator sets which can be properly maintained and serviced without causing the purchaser either to carry expensive parts stock or to be subjected to the inconvenience of long periods of interrupted service because of lack of available parts. The bidder shall specify the nearest location of permanent parts outlets from which parts may be obtained and of local maintenance expertise. Bidders shall offer an annual maintenance contract as a separate offer as detailed in the contract documents.

6.0 UPS

6.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 1363-2	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS 89-series/ BS EN 60051-series	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS EN 60051	Direct acting indicating analogue electrical measuring instruments and their accessories.
BS EN 60073	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators
BS EN 60146	Semiconductor converters – general requirements and line commutated converters
BS EN 60240	Characteristics of electric infra-red emitters for industrial heating. Short wave infra-red emitters
BS EN 60269-1, BS 88-1	Low voltage fuses – General requirements
BS EN 60269-4 / BS 88-4	Low voltage fuses. Supplementary requirements for fuse-links for the protection of semiconductor devices
BS EN 60269-series / BS HD 60269-series / BS 88-series	Low voltage fuses.
BS EN 60447	Basic and safety principles for man-machine interface, marking and identification. Actuating principles.
BS EN 60529	Specification for degrees of protection provided by enclosures
BS EN 60896-21 & 22	Stationary Lead Acid Batteries. Valve Regulated Types
BS EN 60898-2	Circuit breakers for over current protection for household and similar installations
BS EN 60947-5-6	Low voltage switchgear and control gear
BS EN 62007 BS EN 60747	Semiconductor devices
BS EN 62040-4	Uninterruptible power systems (UPS). Environmental aspects. Requirements and reporting
BS EN 88528-11	Reciprocating internal combustion engine driven alternating current generating sets. Rotary uninterruptible power systems
BS EN IEC 62040-1	Uninterruptible power systems (UPS). Safety requirements

STANDARD	TITLE
BS EN IEC 62040-2	Uninterruptible power systems (UPS). Electromagnetic compatibility (EMC) requirements
BS EN IEC 62485-1	Safety requirements for secondary batteries and battery installations. General safety information
BS EN IEC 62485-2	Safety requirements for secondary batteries and battery installations. Stationary batteries
BS EN ISO 7779	Acoustics. Measurement of Airborne Noise
BS EN ISO 9241-300	Ergonomics of human-system interaction. Introduction to electronic visual display requirements

6.2 Units up to 6 kVA

The UPS shall be a self-contained unit complete with integral batteries that is suitable for floor mounting. The system shall be hard wired to the power supply cable via an isolating switch disconnecter. Unless specified otherwise the output shall be single phase and neutral. The unit shall be suitable for either socket-outlets to BS 1363-2, or hard wiring to a distribution board.

A common alarm port, connection to be confirmed by the engineer shall be provided for remote monitoring of alarm status by a BMS system or similar.

Unit rating shall be taken at unity power factor.

The unit shall be installed such that it does not rely on a distributor's means of earthing when operating as an alternative to the normal mains supply, in accordance with BS 7671.

6.3 Units greater than 6 kVA

The UPS shall be a self-contained multiple cabinet system suitable for floor mounting.

Where required the unit shall work in conjunction with an externally cabled bypass. To enable this arrangement to operate both input and output must at all times be synchronised to allow the external bypass to be closed or opened in parallel.

6.4 Common Requirements

Ambient room conditions should be taken as 30°C unless stated otherwise.

Connectors shall be provided for incoming/outgoing neutrals. An earthing terminal shall also be provided.

When the mains supply is restored after a supply failure the UPS system shall initially draw no power, except for transformer inrush current for a UPS with integral transformer. Over a period of 1 minute the power requirement shall rise to a level dictated by the power required to drive the load.

Testing shall be carried out on site in-situ and to cover the following aspects as a minimum:

- Cable connections and external bypass
- Autonomy (Provide suitable load bank)
- Alarms
- General operation including simulated power failure

An oscilloscope (with printer) shall be connected to the output to enable the output waveform to be recorded at critical moments (via printer). This applies to systems above 6kVA only.

6.5 Packaged UPS Parameters

UPS Units shall be suitable for unattended operation indoors, conform to the relevant parts of BS EN 60240 and afford the following input tolerances:

PARAMETER	INPUT TOLERANCE
Voltage tolerances	+/- 4%
Frequency tolerances	+/- 1%
Rate of change of frequency	0.5 Hz/sec:
Harmonic Distortion	12% total harmonic distortion shall not contribute more than 0.6% THD on the output voltage

The UPS shall provide for the following parameters with regard to the output characteristics:

PARAMETER	OUTPUT CHARACTERISTIC
Steady state voltage control	+/- 1%
Transient voltage variation and recovery time	+/- 5% on 100% load change, recovery to within +/- 2% in 10 - 40 ms
Steady state frequency control	+/- 0.5%
Overload:	125% for 10 – 12 minutes. 150% for 2 minutes
Unbalanced loading:	50% unbalance with +/- 3.5% Voltage, +/- 3.0 phase angle deviation
Non-linear loading capability	To provide an output voltage waveform with less than 5% THD when supplying non-linear load, by filter application.
Crest factor:	3:1
Fault clearance capability	400% rated full load current for 1 sec.
Input power factor:	0.8
Full rated load	As defined within the Scope of Works/Schedule or as otherwise specified.
Period of autonomy:	15 minutes, or as otherwise specified or detailed within the scope of works.
Noise Limit	Limit external noise level to 75 dBA, measured 1 m from each surface of the enclosure

6.6 Enclosure

UPS enclosures shall be coloured to manufacturer's standard colours unless otherwise specified.

The enclosures shall be of rigid steel construction to a BS EN 60529 ingress protection rating of at least IP 31. The enclosure shall afford access to the maintainable parts by lockable-hinged doors.

Ventilation shall be provided integral to the UPS by the system manufacturer to enable continued operation at the designed and specified parameters. As a minimum, a dual fan system shall be provided.

An earth terminal shall be made available with the units of minimum dimension ISO M10.

6.7 Parallel Operation

Where multiple UPS units are specified they shall be capable of being connected in a parallel configuration.

6.8 Transformer / Rectifier

The UPS shall be complete with a rectifier, inverter static internal bypass and battery charging system that is capable of continuous operation at the rated full load current in accordance with BS EN 60146.

Unless specified otherwise, 6-pulse transformer/rectifier shall be utilised for outputs up to and including 100 kVA, and 12-pulse transformer/rectifier utilised for outputs over 100 kVA. The transformers and rectifiers shall incorporate phase-shifting of input supplies to multi-unit systems to reduce total harmonic current drawn from mains supply.

Rectifiers shall generally be IGBT type power converters.

The total harmonic current drawn from mains supply shall be limited with the current total harmonic distortion (THDi) limited to 3-4 percent or less.

6.9 Automatic Bypass

The UPS shall be complete with automatic static bypass switch to transfer the load to bypass supply, without a supply break, when output of inverter deviates from specified limits. The internal control mechanism shall be capable of inhibiting the operation of the bypass if the inverter output is not in synchronism with the bypass supply.

The system manufacturer shall ensure that on no account can the output side of the UPS operate with a floating neutral.

6.10 Manual bypass

The UPS shall incorporate internal manual bypass arrangements for completely isolating the equipment from all supplies for maintenance or shall provide for connecting an external manual bypass. The system manufacturer shall ensure that on no account can the output side of the UPS operate with a floating neutral.

Supply and install a TP-N bypass switch to enable the manual switching to take place. The switch shall be fully compatible with the UPS system and be connected in accordance with manufacturer's recommendations. The neutral connection of the bypass switch shall remain linked at all times to prevent a floating neutral.

6.11 Electrical Protection

All switchgear to be included within the assembly and loose form parts shall comply with this document.

The UPS shall incorporate integral protection against damage due to:

- Overload and short-circuit on the output
- Failure of internal components
- Overheating due to failure of internal fans

Fuse combination units shall provide the UPS DC output protection to relevant parts of BS EN 60947 with fuses to the relevant part of BS HD 60269 / BS EN 60269 / BS 88.

Input protection shall be provided by an ac input circuit-breaker to BS EN 60898 or BS EN 60947-2 or provide a fuse combination unit to relevant parts of BS EN 60947 with fuses to BS 88 (BS EN 60269) or Solid-state power component protection. Fast-acting current-limiting devices or fuses shall comply with BS 88 (BS EN 60269).

6.12 Instruments

The UPS shall be supplied complete with flush mounted instruments, indications and controls in dust and moisture resistant cases.

Indications and controls shall comply with BS EN 60073. Where a GUI is used for control and indication, it shall comply with BS EN 60073, BS EN ISO 9241-300, and BS EN 60447.

Voltmeters, ammeters, watt meters, frequency indicators and power factor instruments shall comply with relevant parts of BS 89 and BS EN 60051.

- Input supply voltmeter for 3-phase provide phase-phase and phase-neutral selector switch
- Input supply ammeter with phase-phase and phase-neutral selector
- Output supply voltmeter with phase-phase and phase-neutral selector switch
- Output ammeter with phase-phase and phase-neutral selector switch
- Simultaneous display of all phases required for above meters.

Where possible, the instruments shall be multifunction within an LED screen display or Graphical user interface that affords scroll functions in conjunction with a mimic diagram as detailed below.

6.13 Control and Indication

Each specified unit above 6 kVA shall include a mimic diagram of the main circuit incorporating indicator lights, push buttons, instruments and alarms to indicate the status of the system in accordance with BS EN 60073. Where a GUI is used for control and indication, they shall comply with BS EN 60073, BS EN ISO 9241-300, and BS EN 60447.

LED Indicator lights &/or GUI shall be provided to identify the availability of the incoming supply, battery on boost charge, open or closed state of the circuit breakers, bypass position and if the bypass is inhibited.

The UPS alarms shall include, but not be limited to:

- Incoming supply failure
- Battery discharged
- Battery charge failure
- Battery circuit-breaker or isolator open
- Overload
- Cooling fan failure
- Equipment over temperature
- Output outside limits
- Load on bypass supply

Remote alarms shall be provided as scheduled.

6.14 Inverters

Each UPS shall be provided with static inverters to supply the rated load continuously and 150% rated load for 10 seconds in any period of 15 minutes to BS EN 60146.

The UPS system shall be capable of controlling the output frequency automatically to enable the unit to operate in synchronism with the bypass supply and also to run independently when the bypass supply deviates from the specified limits for voltage or frequency. The units shall afford a manual adjustment for frequency within the range +5% of nominal.

An on-load switch disconnecter shall be provided within the unit at the output of the converter system. The system shall be complete with double-wound output transformer and filters to reduce the harmonic content of the output voltage waveform to the specified limits when supplying the rated output to the load with the indicated characteristics. The system shall comply with BS EN 62007 & BS EN 60747 for the application of thyristors.

The units shall be provided with a facility to compensate for line-drop by a linear increase/decrease of the output voltage with any load current variation to compensate for cabling voltage drop. The facility shall include a manual adjustment for voltage compensation at the full load over the range of 0-5% of nominal voltage.

6.15 Batteries and Charger

The batteries to be provided to form the complete installation shall be of the type determined in the schedules and be complete with sealed connections. The connections shall be intercell type with the output terminal shrouded with impact resistant plastic to protect against inadvertent contact.

Unless specified otherwise, only battery chargers for units above 6kVA shall be provided with instrumentation. Where possible the instruments shall be contained within a common cubicle / compartment.

Where possible, the instruments shall be multifunction within a LED screen display that affords scroll functions in conjunction with a mimic diagram as previously detailed. As a minimum, unless detailed otherwise, the instruments to be provided are to be in accordance with relevant parts of BS 89 and BS EN 60051 and shall comprise, but not be limited to a battery voltmeter and battery ammeter that indicates the battery charge/discharge current.

Mount the batteries on either open type appropriate electrolyte-resistant stands or in proprietary manufactured ventilated steel cubicles as detailed within the design documents. The installation of the batteries shall be defined as Class C in accordance with BS EN 62845-1 and BS EN 62845-2.

Provide a battery charger as part of the installation. The charger shall be a current-limited constant-current / constant-voltage / managed charging type in accordance with battery manufacturer's recommendations.

Provide rigid steel freestanding floor-mounted enclosure with BS EN 60529 ingress protection rating of at least IP31 to contain the charger.

The charger shall facilitate current limiting and fault voltage protection from the transformer/rectifier in accordance with the manufacturer's recommendations; over current and over voltage protection shall also be provided.

Earth fault detection and alarm protection shall be provided where the battery and charging system are not connected to an earthed system, provide battery on-load disconnection and fuses.

The charger shall be capable of limiting load step on supply restoration following a mains failure to 50% of full load, the remaining load shall be gradually stepped to full load. The load step shall be in accordance with the manufacturer's recommendations.

The batteries shall be complete with an on-load disconnecter together with an air circuit breaker.

7.0 Switchgear

7.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6231	Electric cables. Single core PVC insulated flexible cables of rated voltage 600/1000 V for switchgear and controlgear wiring.
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN /IEC 60204-1	Safety of machinery. Electrical equipment of machines. General requirements.
BS EN 547-1	Safety of machinery. Human body measurements. Principles for determining the dimensions required for openings for whole body access into machinery
BS EN 547-2	Safety of machinery. Human body measurements. Principles for determining the dimensions required for access openings
BS EN 547-3	Safety of machinery. Human body measurements. Anthropometric data
BS EN 60038	CENELEC standard voltages
BS EN 60255-series / BS EN IEC 60255-series / BS IEC/IEEE 60255-series	Measuring relays and protection equipment.
BS EN 60269-series / BS HD 60269-series / BS 88-series	Low voltage fuses
BS EN 60282-1	High voltage current limited fuses. Current-limiting fuses
BS EN 61439 BS EN 60439	Low-voltage switchgear and controlgear assemblies. Particular requirements for assemblies for power distribution in public networks.
BS EN 60529	Specification for degrees of protection provided by enclosures.
BS EN 60947-1	Low voltage switchgear and control gear.
BS EN 61082-1	Preparation of documents used in electrotechnology. Rules
BS EN 61111	Live working. Electrical insulating matting.
BS EN 61439	Low-voltage switchgear and controlgear assemblies. General rules
BS EN 61439-2	Low-voltage switchgear and controlgear assemblies Power switchgear and controlgear assemblies
BS EN 61439-5	Low-voltage switchgear and controlgear assemblies. Assemblies for power distribution in public networks
BS EN 62271-1	High voltage switchgear and controlgear. Common specifications for alternating current switchgear and controlgear.
BS EN 62271-100	High voltage switchgear and controlgear. Alternating current circuit breakers

STANDARD	TITLE
BS EN 62271-105	Specification for high-voltage alternating current switch-fuse combinations
BS EN 62271-106	High-voltage switchgear and controlgear. Alternating current contactors, contactor-based controllers and motor-starters
BS EN 62271-200	AC metal-enclosed switchgear and control gear for rated voltages above 1 kV and up to and including 52 kV
BS EN 62305-series	Protection against lightning. Risk Management
BS EN 62771-series / BS EN IEC 62771-series	High voltage switchgear and controlgear
BS EN IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) and complementary gases to be used in its mixtures for use in electrical equipment
BS EN/IEC 60376	Specification of technical grade sulphur hexafluoride (SF6) and complementary gases to be used in its mixtures for use in electrical equipment
ENA Technical Specification 41-36	Switchgear for service up to 36 kV (Cable and Overhead conductor connected)
ENA Technical Specification 41-38	Power installations exceeding 1 kV a.c. – Design of high-voltage open-terminal stations
ENA Technical Specification 41-40	Ground Mounted Major Substation 12 to 36 kV Rated Indoor Fixed Pattern Switchgear
ENA Technical Specification 41-41	Ground Mounted Distribution Substation 12 to 24 kV Rated RMU & Extensible Switchgear
Statutory Instrument 2015 No. 310	Fluorinated Greenhouse Gases Regulations 2015

7.2 General

Supply, install, connect, test and commission the switchgear described in the Particular Specification, schedules and on the drawings to make a complete and fully operational installation.

All switchboards shall be of the same manufacture so far as practicable. All items of loose gear shall be of the same manufacture.

No deviations from or alternatives to the Particular Specification, Schedules or Drawings will be accepted unless approved by the Engineer in writing.

Ensure all new equipment containing sulphur hexafluoride (SF6):

- complies with the Fluorinated Greenhouse Gases Regulations 2015 (as amended)
- allows for recycling of SF6 during maintenance and decommissioning
- complies with BS EN IEC 60376.

Include manufacturer's information on SF6 leak reduction methods in the operating and maintenance manuals for all SF6 equipment.

7.3 Switchboard Drawings

Submit with the tender a dimensioned outline drawing of each switchboard showing all leading dimensions and the estimated weight of the board.

Immediately after receiving instructions to proceed and before manufacture commences submit to the Engineer, for approval, fully detailed layout drawings, general arrangements drawings, and wiring and schematic diagrams, prepared in accordance with BS EN 61082-1, showing clearly all significant details of each switchboard, including the following:-

- a) Equipment incorporated in the switchboard
- b) Fuse, circuit-breaker and switch ratings
- c) Current and voltage transformer ratios, class, terminal markings and output
- d) Instruments, including scale details
- e) Relay types and characteristics
- f) Indicating lamps, including colour
- g) All internal connections, with terminal markings

(Note that circuit diagrams shall show all switches, relays, contactors, etc., in the open or de-energised condition).

- h) Arrangement of terminal boards
- i) All plug contacts
- j) Wire numbers
- k) Size, type and colour of secondary wiring
- l) Principal physical dimensions, including clearances taking into account space required for maintenance access in accordance with BS EN 547-series, required for removing covers, opening doors, operating handles, withdrawing equipment, or maintenance access
- m) Position of all panel face equipment, including dimensions of all projecting apparatus
- n) Identification of all equipment, with type references, and the appropriate label inscriptions
- o) Foundation details, including weights, support points, and any reinforcement of foundations needed, to withstand dynamic forces arising from switchgear operations under normal service or fault conditions
- p) Cable entry details including gland and gland plate provisions
- q) Principle overall dimensions with sectional details for transportation and installation, including any special provisions require for site restrictions from off-loading point to final position

Approval of drawings does not imply acceptance of deviations from relevant standards or the detailed requirements of this specification. Any such items must be specifically raised with the Engineer for their written approval.

7.4 High Voltage Switchgear

Where applicable all equipment and accessories to be utilised for high voltage systems, above 1,000 V AC and 1,500 V DC shall comply with relevant parts of BS EN 62271 / BS EN IEC 62271 and relevant ENA Technical Specifications.

All switchgear and controlgear, including ring main units, shall be capable of containing the overpressures of an internal arc to protect personnel. Where the products of an internal fault cannot be contained within an assembly to protect personnel from the effects of arc flash, it shall be provided with ducts and accessories to divert the products of arcing away from an operator.

The contractor shall provide manufacturer's data on the overpressures produced within an enclosures space by an internal arc fault.

The contractor shall liaise with the architect in respect of the suitability of the proposed location of switchgear and controlgear based on its ventilation pressure and product expulsion requirements.

Where the overpressure resulting from by an internal arc exceeds the pressure that can be withstood by the switch room structure, particularly walls and ceilings, the products of arcs shall be managed by a combination of one or more of the following to prevent structural damage:

- Venting to a safe location outside the switchroom
- Providing pressure relief dampers within the switch room structure.

The switchboard and any arc containment apparatus and ducts shall be provided with purpose-made plinths and supports.

7.5 HV switchgear and Control gear Enclosures

Supply and install the switchboards as scheduled or as indicated on the drawings. The enclosures shall be cubicle or multi-compartment type in accordance with BS EN 60529, IP41 rated for indoor switchboards and IP65 for external switchboards.

Unless otherwise specified, each switchboard supplied under this contract shall be extendable

7.6 HV Circuit Breakers

Provide circuit breakers in accordance with BS EN 62271-100 of the type, application and operating mechanisms indicated on the schedule or drawings.

Withdrawal type circuit breakers shall accommodate automatic shutters to cover high voltage contact spouts when the circuit breaker is removed from the fixed compartment.

Each circuit breaker shall facilitate a mechanical indicator to identify when the contacts are open or closed, the indicator shall be visible through a window aperture within the circuit breaker enclosure.

Circuit breakers shall incorporate a manual trip facility with a shunt trip mechanism at the voltage level detailed either in the schedules or on the drawings.

Circuit breakers shall accommodate an integral fault making earth switch with a rated short time withstand current as indicated for the switchboard circuit earthing and/or busbar earthing as indicated on the drawings.

The circuit breakers shall incorporate padlocking facilities to enable locking of the breakers and switches in the ON, OFF and EARTHED positions.

When isolated from the system the circuit breakers shall readily allow the testing and proving of the operation of the circuit breaker closing, tripping, interlocking, intertripping, protection devices, indicator lights, remote control, indication and alarm systems.

Circuit breakers shall enable their secondary circuits to be operationally tested with the circuit breaker isolated from main circuit.

7.7 HV Motor Starters & Contactors

Provide motor starters and contactors of the type and application as indicated on the schedules and drawings in accordance with BS EN 62271-106 and other relevant parts of BS EN 62271 / BS EN IEC 62271.

All starters shall have a sensitive discriminating thermal magnetic over current relay with precise time/current characteristics to relevant parts of BS EN 60255 / BS EN IEC 60255 / BS IEC/IEEE 60255. The starters shall be capable of providing sustained and cyclic over current for the connected motors.

Starters shall provide motor protection for unbalanced phase currents, motor stalling and earth faults.

Starters shall utilise BS EN 60282-1 HRC fuses that incorporate striker pins to ensure three phase isolation under short-circuit conditions.

Provide all control circuitry for motor starters and contactors and operating devices to suit application. Unless specified otherwise, the control circuitry shall be derived from a centre-tapped to earth 110-V secondary transformer.

Each high voltage contactor shall be withdrawal type unless detailed otherwise and shall incorporate automatic shutters to cover the high voltage contact spouts when the contactor is removed from fixed compartment.

A means of indicating the contact position of each contactor shall be incorporated into all HV contactors.

Unless specified otherwise, the operating mechanism for HV contactors shall be electrically retained with a manually operated trip facility.

Contactors shall accommodate an integral fault making earth switch with a rated short time withstand current as indicated for the respective switchboard.

Contactors shall incorporate padlocking facilities to enable locking of the contactor and the earth switch in the OFF and EARTHED positions.

When isolated from the main system the contactors shall readily allow the testing and proving of the operation of the contactor closing, tripping, interlocking, protection devices, indicator lights, remote control, indication and alarm systems.

7.8 HV Ring Main Units

7.8.1 Performance Objectives

Supply and install ring main units connected into the HV cable distribution system to enable distribution transformers to the HV infrastructure as indicated within the schedules, drawings and particular specification(s). The ring main units will provide electrical protection to the transformer feeders.

7.8.2 Codes and Standards

All equipment shall be designed and manufactured to the latest revision of the following International and British Standards except where specifically defined otherwise: -

Relevant parts of BS EN 62271 / BS EN IEC 62271 High voltage switchgear and controlgear.
Oil immersed ring main units shall be in accordance with BS EN 60129, BS EN 60282 and BS EN 60420.

7.8.3 Technical Requirements

The RMU shall be capable of being operated in exposed locations and capable operating at high relative humidity and ambient air pollution in accordance with the project design parameters.

The RMU shall be selected from one of the approved HV switchgear manufacturer's range of proprietary equipment. They shall be compact, low maintenance, easy to install, safe and easy to operate and have readily available parts.

The active parts of the switchgear shall be maintenance-free.

Welded steel/stainless steel SF6 enclosures or a dual skin type design shall not be acceptable. Each RMU shall be identified by an appropriately sized label which clearly indicates the functional units and their electrical characteristics.

The unit shall have the option to be fitted with a multi-tap shunt trip coil and auxiliary switch for remote tripping/indication of the tee off circuit breaker.

Bushings shall be accessible from the rear and sides of the RMU. Bushings along the front of the RMU are not acceptable.

All of the cable boxes shall be air insulated suitable for dry type cable terminations. Compound filled cable boxes are not acceptable.

The cable boxes at each of the two ring switches shall be suitable for accepting H.V. cables approaching from above or below. Access to the ring switch cable boxes shall be available from 180° (two sides) excluding the gland plate.

The tee off circuit breaker shall be suitable for direct coupling to a transformer flange to ENA specifications.

The circuit breakers and switches shall be locked in the open/closed or earth on position by 1 to 3 padlocks to Utility Company standard requirements.

The ring main units shall comprise two fault-making, load-breaking, ON/OFF/EARTH switches for control of the high/medium voltage distribution ring circuit or designated distribution network. Where SF6 type ring main units are to be used the switches shall be contained within a tank charged with sulphur hexafluoride to a pressure recommended by the manufacturer and compliant with BS EN 60376.

Where SF6 circuit breakers are used warning notices shall be displayed on the external face of each door leading into the switch room/enclosure and also within the switch room/enclosure. The notice shall identify that there is a pressurised gas within the room and clearly denote that the gas is SF6.

Oil immersed ring main units shall comprise a manually operated fault-making, load-breaking, oil-immersed fused-switch for ON/OFF control of the outgoing circuit with a trip-all phase mechanism and striker pin fuses. Access to the fuses shall be interlocked to enable access only when the fuses are disengaged and isolated from any source of supply as well as the outgoing cabled circuit.

The outgoing feeder section of SF6 type circuit breakers shall incorporate SF6 circuit breakers in accordance with the previously described British Standard and charging pressure. They shall be complete with fault-making outgoing tee off earthing switches.

Oil immersed circuit breakers shall incorporate a manually operated oil immersed outgoing circuit earthing switch and shall include neon 'live' indicators on the feeder sections.

A mimic legend shall be incorporated on the lid of the SF6 type ring main units that identifies, closed, open and earth position when switched.

Circuit breakers and ring switches shall be complete with a facility to padlock switches in the closed, open or earthed positions.

Supply and install an emergency trip circuit control circuit to isolate the HV/MV switchgear scheduled or identified on the drawings.

Each of the functions on the RMU shall be equipped with a voltage indication, to indicate whether or not there is voltage on the cables. The capacitive dividers will supply low voltage power to sockets at the front of the unit, an external lamp shall be used to indicate live cables.

Three outlets shall be used to check the synchronisation of phases with the use of an external device. This device shall be in compliance with BS EN 62271-206 standard.

The front shall include a clear mimic diagram which indicates the different functions. The position indicators shall give a true reflection of the position of the main contacts. They shall be clearly visible to the operator. The lever operating direction shall be clearly indicated in the mimic diagram. The manufacturer's plate shall include the switchboard's main electrical characteristics.

Cables shall comprise 12kV grade armoured cable having copper conductors. All cables shall be supplied and installed in accordance with the Standard Electrical Specification using proprietary fixings and supports to the manufacturer's requirements.

Cables shall be terminated at the equipment served by a mechanical type cable gland, complete with armouring clamps.

7.9 HV Metering

Provide where shown on the drawings a dry type metering unit that comprises an enclosure that accommodates two wound primary current transformers and two single phase voltage transformers that are to be encapsulated in a moulding and totally enclosed in a weatherproof ventilated steel chamber.

The metering unit shall be bolted and connected onto the outgoing circuit breaker that is teed off the ring main unit.

Provide a separate enclosure to house the current transformer secondary winding terminals, the voltage transformer output fuse cartridges, fuse bases and fuse carriers.

7.10 Circuit Breaker Trip Panel

Provide a self-contained control panel assembly to operate the circuit breakers as detailed on the schedule or drawings. The control panel shall be of suitable voltage output and frequency to operate the required circuit breakers.

The panel shall be IP 31 rated, finished in a manufacturer's standard colour and accommodate Nickel Cadmium batteries achieving a 25-year design life that afford maintenance free operation.

The panel shall incorporate MCB protection for the input and outgoing circuits, and fuses for the battery protection.

The charger shall afford float charge with automatic boost charge selection and be capable of providing a minimum of five operations under all conditions.

Analogue metering shall be provided with the panel to identify the battery voltage and the current for both charge and discharge.

Indicator lamps shall be provided with the panel to identify the following:

- Supply on
- Supply failed (monitor input terminals)
- Float charge
- Boost charge
- No charge (when mains supply is available)
- Battery voltage low
- Battery voltage high

- Earth fault on output

A common alarm facility shall be available from the panel to operate a relay. Unless otherwise specified, the minimum requirement shall be:

- Supply failed
- No charge (when mains supply is available)
- Battery voltage low
- Battery voltage high
- Earth fault on output

7.11 Circuit breaker Trip / Close Switches

Provide remote emergency trip buttons as indicated. The operators shall be mushroom-headed actuators, latching type, red coloured push buttons to BS EN 60947-5-1. They shall be released by twisting the actuator or means of a key. Where key type operators are provided the key shall be handed over to the engineer upon completion of the works.

Each circuit breaker that is to be fitted with electrically operated closing mechanisms shall be complete with a heavy duty, spring return key operated trip/close switch.

Where remote trip/close is required the circuit breaker mounted operator and remote operator shall be compatible for remote operation such that the remote or local operation of the device does not prevent circuit-breaker tripping under fault conditions.

7.12 Low Voltage Switchboard Construction

All of the switchgear described herein shall be suitable for connection to a 400/230 V 3-phase 50 Hz 4-wire supply alternating current system (BS EN 60038).

Each switchboard shall be so designed and constructed that it will withstand for three seconds without damage, the thermal and mechanical stresses which might arise under short circuit conditions for a prospective busbar short circuit current of 50kA unless otherwise specified on the drawings or in the particular specification. The fault rating shall apply to the whole of the busbar system up to the connection to outgoing protection devices.

Each switchboard shall conform to the requirements of BS EN 61439-2, Form 4b Type 5, except where more onerous conditions are specified elsewhere, in which case the qualification shall prevail.

Unless more stringent conditions are specified elsewhere in the documents, each switchboard shall provide a degree of protection against contact with live or moving parts, and against the entry of solid foreign bodies and liquid, to the IP standard 41 in accordance with the definitions contained in BS EN 60529.

Switchboards shall be so constructed to allow inspection, cleaning and maintenance of all equipment and to ensure safety during operation. Switchboards shall be compartmentalised to minimise the risk of fire arising and spreading.

Each switchboard shall incorporate all of the items of equipment detailed in the Schedules and/or as shown on the Drawings. The switchboard shall be complete with all necessary control and associated equipment including instruments, interlocks, fuses, relays, current transformers, terminal blocks, cable ways and interconnections as necessary to provide a fully working system.

Cable terminations and gland boxes shall be suitable for the practical installation of sizes of cable called for in the design and shall not be limited to mere compliance with relevant parts of BS EN 61439.

Each switchboard shall be provided with a fully type tested certificate covering the principle elements of construction. The certificate must be obtained by the manufacturer and "third party" compliance will not be accepted.

Access to busbars and busbar connections shall be possible only after the removal of covers secured by bolts or studs. Such covers shall be identified by Traffolyte labels bearing the inscription 'BUSBARS' in red lettering not less than 10 mm high, on a white background.

The cross-sectional area of the neutral busbar shall equal that of the associated phase bars.

Each cubicle or box sections shall be provided with sufficient busbar links to enable cubicle sections to be easily joined. Facilities shall also be provided for extending the busbars to extra cubicle sections, if required, at some later date.

Where so specified in the Schedule or on the Drawings, provision shall be made for metering current transformers and other metering equipment as required by the Distribution Network Operator. A separate cubicle shall be allowed for the metering equipment.

All busbars shall be fully shrouded with shrink on sleeves and where a significant number of copper terminations are exposed by the removal of the rear panel (for example in changeover contactor/switch sections) a secondary Perspex sheet to protect from contact with exposed parts shall be fitted.

All small wiring shall comply with BS 6231 shall be neatly bunched and cleated in harness form using purpose-made plastic cable ties, or shall be enclosed in purpose-made plastic small wiring trunking. Wiring cleated to metal surfaces shall be spaced off the metal or otherwise insulated from it. Metallic 'buckle clips' shall not be used for internal wiring. Wiring to swing doors or other moveable items shall be by flexible cables, neatly bunched and constrained by a flexible harness or loom.

Small wiring to which external connections are to be made, shall be terminated on approved type terminal boards, which shall be easily accessible and conveniently arrange to facilitate the connection of incoming and outgoing multi-core cables.

Each terminal unit shall have separate incoming and outgoing terminals and no more than one wire shall be connected to any one terminal unless the terminal is specifically designed to take more than one.

All spare contacts on relays, contactors, and the like shall be wired to easily accessible terminal blocks, as above, suitably positioned for future external wiring.

Each terminal board for external wiring shall have a least 10% spare capacity with a minimum of two spare terminals.

All terminal boards shall be numbered in sequence to match the numbering on the wiring or connection diagrams.

Cubicles shall be arranged in a neat and modular form to facilitate easy lengthways extension for future requirements. They shall be constructed from Zintec steel panels, with minimum thickness of 2 mm on a steel angle frame. Individual panels shall be no greater than 2,000 mm unless approved by the Engineer. Doors and covers shall be of dish construction fabricated from minimum 2 mm (14 SWG) gauge sheet Zintec with rounded edges and corners and concealed hinges. Doors and covers shall incorporate neoprene gaskets and thumb screw fasteners. Panel doors shall be readily removable by authorised personnel.

Each cubicle section shall be provided with eye bolts, located in reinforced top frame members, to facilitate hoisting into position. Purpose made holding down brackets shall be provided at the bottom of each panel section for corrosion resistant anchor bolts of adequate size for the switchboard.

Top entry/exit switchboards shall incorporate aluminium glanding plates of minimum thickness 6 mm. Switchboards with bottom entry facilities shall incorporate U channel apertures on the base with vermin proof split steel shields. Glanding shall be by means of aluminium plates above these apertures, located a minimum of 450 mm above finished floor to facilitate cable and gland installation. Busbars are to be enclosed in separate components of switchboards and shall be so arranged that all conductors can be brought onto the bars without undue bending. The lowest point of any switch or termination shall be a minimum of 700mm above the finished floor level.

Main and secondary busbars shall be positioned in the sequence L1 (Brown), L2 (Black), L3 (Grey) and Neutral (Blue), top to bottom for horizontal bars and left to right for vertical bars.

Main and secondary busbars shall be fully insulated using Brown, Black, Grey and Blue polyshrink insulation to identify phases L1, L2 and L3 respectively in accordance with BS EN IEC 60445 and BS 7671.

Outgoing terminations from associated devices shall be extended via additional copper bars to termination chambers via insulated bushes and PVC shrouds, thus ensuring safe cubicle live re cabling facilities. All switchgear and fuse board chambers shall be adequately enclosed to prevent items dropping onto live sections during maintenance.

Bus-bars and connections shall be formed from HDHC copper to BS EN61439 and shall be of an Intertek ASTA or BEAB certified design. Bus bars shall be supported by means of glass fibre reinforced arc resistant supports. Bends shall be made on radiused formers adequately sized to avoid distortion. All bus-bar chambers shall be constructed to comply with relevant parts of BS EN 61439

Floor mounted switchboards will be mounted on 75mm high plinths. Provide the necessary builders work drawings to ensure the plinths can be accurately constructed.

Wall mounted switchgear cubicles shall be securely fixed via internal lugs to a minimum 38 x 38 x 6mm angle iron bracing and fixed to the wall. The frame shall be anti-rust treated and durably painted to match the switchgear colour.

Panel switchboards, where detailed, shall comprise a factory assembled, fully shrouded busbar assembly with an incoming air circuit breaker, fuse switch, MCCB or switch, disconnecter and outgoing MCCB's or fused switches all mounted within a sheet steel enclosure. The assembly shall accept four, triple or single pole outgoing MCCB's or fuse switches to suit the project requirements.

All terminals shall be shrouded and blanking pieces fitted over spare ways.

The assembly shall include a hinged lockable front cover if it is not located in a lockable room/cupboard which is exclusively for electrical equipment. The assembly shall be constructed to comply with BS EN 61439-2 shielding for separation of live parts to form 4b type 5. Panel boards shall be generally arranged for wall fixing to suit any structural constraints.

7.13 Switchboard Earthing

As well as the integral main earth bus bar the switchboards shall be complete with a 25 mm x 3 mm (minimum) copper earth tape extending the full length of the switchboard bonding all gland plates fuse switches, isolators and other components parts of the switchboard to a main earth point adjacent to the switchgear.

Glands with earth lugs must be used for all armoured cable terminations onto the switchboards.

Where necessary and unless specified otherwise or detailed on the drawings, the main neutral earth link shall be integral to the main intake switchboard.

Where bus couplers or any other form of device is incorporated to sectionalise the switchboard neutral bus bar then a neutral earth link shall be provided for each separated section of the switchboard.

7.14 Labelling

Engraved labels shall adequately describe the function and operation of every switch, indicator, relay, meter, and the operational procedure for each complex switching system.

Labels shall be Traffolyte having white fascia and black lettering (minimum height of letter 5 mm). Each label shall be secured by at least 2 No. 2 mm chromed raised head bolts, locked in position by a serrated washer beneath each nut.

Each label shall contain the following information as a minimum.

- a) Circuit reference
- b) Item description
- c) Current rating

A schedule of proposed labels shall be submitted to the Engineer for comment prior to manufacture.

Warning labels shall be fitted in all places where the removal of covers or access panels may expose live equipment operating at 50 V or more between phases or to earth.

Warning labels shall be Traffolyte with black lettering on a yellow background, and shall bear the inscription 'DANGER - LIVE PARTS OVER 230 V' in letters not less than 10 mm high accompanied by the lightning bolt in a triangle registered safety sign as per BS EN ISO 7010 reference W012.

All equipment and apparatus, both inside and outside the switchboard, including instruments, meters, and relays, which is not clearly identified by integral labelling, shall be adequately labelled in the manner described above.

7.15 Protective Relays (HV & LV)

All protective relays shall be to relevant parts of BS EN 60255 / BS EN IEC 60255 / BS IEC/IEEE 60255.

All protective relays shall be of the withdraw able type and shall be housed in flush-mounted black plastic cases.

Protective relays shall be set by the manufacturer at the works and commissioned and checked on site by the manufacturer after switchboard installation.

Unless otherwise detailed, protection relays shall be of the self-powered electronic type and afford multiple characteristic curves.

The factory commissioning testing of the relays shall include primary and secondary injection tests and all results shall be forwarded to the engineer for inspection. The injection tests shall be made over the complete setting ranges of the relays. Any faults found during the factory testing of the relays shall be remedied prior to acceptance by the engineer.

All current transformers and equipment associated with protection systems shall be class 10P.

7.16 Metering

Cubicle switch panels shall be complete with voltmeters to monitor the voltage between each phase and neutral and between each phase. Suitable rotary selector switches shall be installed to allow the changeover between phases. 4 No maximum demand reading ammeters shall be installed to monitor the line and neutral

currents. Where specified, metering to detail harmonic analysis up to and including the 29th harmonic shall also be provided. Power factor correction meters shall be provided where specified. Current transformers for current monitoring will be constructed to a minimum standard of class 1.

Cartridge fuses will be inserted in the lines to voltmeters.

Unless specified otherwise, all metering shall be capable of being integrated with an external energy management system (EMS). The protocol and type of output required for each meter shall be made available by the engineer prior to panel construction.

7.17 Fuses

All fuses and fuse links will be of the cartridge pattern type and be manufactured and be in accordance with BS EN 60269 / BS HD 60269 / BS 88.

7.18 Surge Protection

Unless otherwise specifically stated, each main distribution switchboard shall incorporate a 400 V rated electronic surge protection device selected in accordance with BS EN 62305-series and BS 7671, that is to be contained within a compartment within the switchboard.

The protection unit itself shall be contained within a clear enclosure and fixed to the switchboard on a mounting plate

The supply shall be derived from a dedicated outgoing way within the switchboard. The device rating shall be determined by the manufacturer.

All other surge protection devices that are to be provided are detailed within the schedules or on the drawings.

7.19 Painting

All steel utilised for the construction of the switchboard shall be electro zinc plated. (Zintec). Prior to painting the steel work shall be degreased and be provided with a minimum of a 2-coat stove enamel or sintered powder finish.

The colour finish of the panel shall be from the manufacturer's standard range unless specified otherwise.

7.20 DC Tripping Power Systems

7.20.1 Scope

To provide self-contained tripping battery assemblies to operate the circuit breakers as defined in the drawings and particular specification. The tripping battery assemblies shall be of suitable voltage output and frequency to operate the required circuit breakers, auxiliary equipment, protection relays, multifunction metering and Monitoring equipment.

Each unit consists of a single battery bank, a single constant voltage charger, instrumentation panel, alarm control system and distribution section. The equipment requirements shall be accommodated in a standalone sheet steel cubicle.

Isolation diodes shall be incorporated onto the DC output of each system to prevent back feeding into the duty or standby system in the event of a fault.

7.20.2 Charger

Thyristor controlled constant voltage type having IU characteristics, at full rated output as listed.

The charger shall afford float charge with automatic boost charge selection and be capable of providing an operation defined in the project specification under all conditions.

The charger shall utilise temperature compensation of float voltage with battery temperature sensing.

Charger output ripple limited to less than 2% RMS.

7.20.3 Cubicle

Each cubicle shall be provided with cable entry points via undrilled gland plates, all steel utilised for the construction of the switchboard shall be electro zinc plated. (Zintec). Prior to painting the steel work shall be degreased and be provided with a minimum of a 2-coat stove enamel or sintered powder finish.

The colour finish of the panel shall be from the manufacturer's standard range unless specified otherwise.

The Charger unit shall be accommodated in the top section, with internal component access via a lockable door. The Battery shall be accommodated in the bottom section with access via a lockable door. Floor standing cubicles to incorporate raised channel sections to prevent moisture damage and provided with lifting eye facilities.

7.20.4 Power Factor

Greater than 0.8 lagging at float voltage, full load current, nominal mains supply and nominal number of cells.

7.20.5 EMC

The equipment is to be EMC compliant to Environment B (domestic and light industrial) as defined in BS EN 61439-1 for susceptibility and emissions.

7.20.6 Battery Disconnection

Disconnection of the battery bank shall not affect the existing operation of the associated switchgear.

7.20.7 Control Circuitry

The switching/tripping units for 400 V systems shall provide shunt trip operation not under voltage release.

7.20.7.1 Temperature

- Nominal 40°C
- Range - 15°C to + 55°C
- Cooling by natural convection
- Derate at 1% per °C above 40°C

7.20.7.2 Electrical

All wiring to be suitably marked and neatly loomed into trunking or fixed into position using tie wrap bases. AC wiring shall be identified by BLACK containment, sheathing or spiral wrapping, DC wiring shall be identified by GREY containment, sheathing or spiral wrapping (unless otherwise specified). The function of wiring shall be in accordance with BS EN IEC 60445, or, for wiring forming part of Machinery as defined in the Supply of Machinery (Safety) Regulations, BS EN 60204-1.

1. All control wiring shall be tri-rated switchgear wire to BS 6231 with a minimum cross-sectional area of 0.5 mm²
2. All secondary AC and DC cables will be tri-rated, switchgear cable to BS 6231
3. M6 earth stud to be provided, for supplementary earth termination; internal earthing to match primary wire size
4. All terminations shall be clearly labelled (in accordance with circuit diagrams) with alphanumeric cable or wire marking sleeves
5. Terminations shall be via cable crimp terminals

7.21 Mats

All electrical switchboards in switch cupboards and plantrooms shall be provided with a 1m wide carbon free rubber mat or mats, having a cross ribbed upper surface and being of such continuous length to suit the full operating extent of each switchboard. The mats shall be in compliance with BS EN 61111 and be fitted to the front of front access panels and to the front and rear of front/rear access panels.

8.0 Air Circuit Breakers and Switches

8.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 60269-1 , BS 88-1	Low voltage fuses – General requirements
BS EN 60947-1	Low Voltage switchgear and controlgear. General rules
BS EN 60947-2	Specification for low-voltage switchgear and controlgear. Circuit-breakers
BS EN ISO 14001	Environmental management systems. Requirements with guidance for use

8.2 General

- Air circuit breakers (ACB) shall comply with BS EN 60947-1 or BS EN 60947-2 or standards derived from the latter; optional version may comply with UL / ANSI / JIS standard
- The ACB breaking capacity performance certificates shall be available for category B according to IEC 60947-2 standards. Air circuit breakers shall have a breaking capacity justified by calculations taking into account their installation location. For main feeders (above 1600 A), the test shall be carried out with a breaking performance during operation (LCS) and admissible short time withstand (LCW) equal to the ultimate breaking capacity (LCU)
- All Air circuit breakers can be reverse fed without reduction in performance
- All Air circuit breakers shall have a rated operational voltage of 690 V AC (50/60 Hz)
- The rated insulation voltage shall be 1000 V AC (50/60 Hz)
- All circuit breakers shall be fully tropicalized as standard
- Air circuit breakers shall be suitable for isolation according to BS EN 60947-1 and BS EN 60947-2 for the rated insulation voltage of 1,000 V and for the overvoltage category IV

8.3 Construction

8.3.1 Environmental Aspects

Production site organisation shall be certified to comply with BS EN ISO 9002 and BS EN ISO 14001 standards.

Air circuit breakers shall be supplied in recyclable packing complying with European Directives. The manufacturer shall implement non-polluting production processes that do not make use of chlorofluorocarbons, chlorinated hydrocarbons, ink for cardboard markings, etc.

Environmental considerations and processing of materials at end of service life.

The manufacturer shall provide instructions on the removal, dismantling and processing of Air circuit-breaker materials at the end of service life (material composition, weight, toxicity).

8.3.2 General Features

Air circuit breaker shall be designed in such a way that maintenance may be carried out as a function of their use. To reduce maintenance, electrical endurance shall be greater than 12,500 cycles up to 1,600 A, 10,000 cycles up to 4 kA and 5,000 cycles for values greater than 4 kA.

No safety clearance shall be required around drawout circuit breakers. For fixed circuit breakers, 150 mm of free space shall be provided above the arc chutes to allow removal of the latter.

The operating mechanism shall be of the Open/Closed/Open stored-energy spring type. The closing time shall be less than or equal to 70 ms.

Air circuit breakers main contact shall be encased in a reinforced polyester casing and offer double insulation from the operators on the breaker front face.

8.3.3 Main Contacts

The main contacts shall be designed such that no maintenance shall be required under normal conditions of use.

The main contacts shall be equipped with a visual wear indicator that may be accessed by removing the arc chutes, for immediate assessment of contact wear without requiring measurements or specific tools.

8.3.4 Arc Chutes

The arc chutes shall be removable on site.

Air circuit breakers shall be equipped with metal filters to reduce effects perceptible from the outside during current interruption.

8.3.5 Drawout mechanism

The drawout operation shall be possible through a closed door.

Three positions of the moving part shall be possible:

1. Connected Position – all auxiliary and main circuits engaged
2. Test Position – all auxiliary circuits engaged; all main circuits disconnected
3. Isolated Position – all circuits disconnected

8.3.6 Safety Requirements

A door interlock shall be provided so that it shall not be possible to open the door until the air circuit breaker moving part is in the disconnected position.

Insulated safety shutters shall be provided over the incoming and outgoing main circuits and over the auxiliary circuits. An interlocking shall be provided to prevent insertion of a circuit breaker having a rating higher than the current rating of the fixed part, into that fixed part.

The racking handle shall be stowed on the air circuit breaker in such a manner as to be accessible without defeating the door interlocking.

8.3.7 Electrical auxiliaries

All electrical auxiliaries including the motor spring charging mechanism shall be field adaptable without adjustment or the necessity for any tool (except a screwdriver). They shall be fitted into a compartment which under normally loaded conditions has no metalwork energized from the main poles exposed with it.

Any adaptation carried out thus shall not increase the breaker volume.

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.

8.3.8 Mechanical indicators

Mechanical indicators on the front panel of Air circuit breakers shall indicate the following status conditions:

- | | |
|--------------------------------|---|
| 1. "ON" (main contacts closed) | Spring charged |
| 2. "ON" (main contacts closed) | Spring discharged |
| 3. "OFF" (main contacts open) | Spring charged – circuit breaker ready to close |
| 4. "OFF" (main contacts open) | Spring charged – circuit breaker not ready to close |
| 5. "OFF" (main contacts open) | Spring discharged |

8.4 Overcurrent Protection

8.4.1 General

The ACB control unit shall be interchangeable on site for adaptation to changes in the installation.

Sensors shall be non-magnetic or of the Rogowski type for accurate current measurements up to LCS value.

The ACB control unit shall measure the true rms value of the current.

The ACB control unit shall comprise a thermal memory to store temperature-rise data in the event of repeated overloads or earth faults.

8.4.2 Protection

The ACB control unit shall offer the following protection functions as standard:

- Long-time (LT) protection with an adjustable current setting and time delay
- Short-time (ST) protection with an adjustable pick-up and time delay
- Instantaneous (INST) protection with an adjustable pick-up and an OFF position

Current and time-delay settings shall be indicated in amperes and seconds respectively on a digital display.

Earth-fault protection with an adjustable pick-up and time delay shall be provided if indicated on the appended single-line diagram.

8.4.3 Additional protection functions

The ACB control unit shall offer the protection functions listed below.

	THRESHOLD	TIME DELAY
Minimum voltage	100 V to U_{max} pickup threshold	1.2 to 5 s
Maximum voltage	U_{min} pickup threshold to 1,200 V	1.2 to 5 s
Voltage unbalance	2 to 30% U_{mean}	1 to 40 s
Minimum frequency	45 Hz to F_{max} pickup threshold	1.2 to 5 s
Maximum frequency	F_{min} pickup threshold to 440 Hz	1.2 to 5 s

	THRESHOLD	TIME DELAY
Current unbalance Maximum current	5 to 60% I_{mean} 0.2 I_n to I_n	1 to 40 s 15 to 1500 s
Phase rotation	L1, L2, L3 anticlockwise	0.3 s
Reverse power	5 to 500 kW	0.2 to 20 s

8.4.4 Maintenance

The last ten trips and alarms shall be stored in two registers that may be consulted locally (date and time, type of fault or alarm).

Maintenance indicators shall be displayable on request on the front panel:

- Contact wear
- Operations counter

8.4.5 Communication option

On option Air circuit breakers shall be capable of communicating the following data via a bus:

- Circuit-breaker status (open / closed, connected / disconnected / test, tripped on a fault, ready to close).
- Control-unit settings.
- Tripping causes.
- The measurements processed by the control unit: current, voltage, frequency, power, power quality.

It shall be possible to remotely control the circuit breaker.

It shall be possible to remotely modify circuit-breaker settings:

- Settings within the range defined by the switches on the front panel of the control unit.
- Settings of the protection functions and the alarms.

Communications functions shall be independent of the control unit.

8.4.6 Measurements

An ammeter with a digital display shall indicate the true rms values of the currents for each phase.

A LED bar-graph shall simultaneously display the load level on the three phases.

A maxi-meter shall store in memory and display the maximum current value observed since the last reset. The data shall continue to be stored and displayed even after opening of the circuit breaker.

8.4.7 Power measurements

The ACB control unit shall measure voltages and calculate power and energy values.

These values shall be displayable on the screen and updated every second. The minimum and maximum values shall be stored in memory.

	Accuracy
Energy (kWh)	2 %
Real power (kW)	2 %
Apparent power (kVA)	2 %
Demand power (kWh)	2 %

8.4.8 Measurement of power quality

The control unit shall offer functions allowing the analysis of the quality of AC distribution system power, including:

- Measurement of the amplitude and phase of current and voltage harmonics up to the 31st order
- Measurement of the fundamental components of the voltage, current, active power, reactive power and apparent power
- Measurement of total current and voltage harmonic distortion.

8.4.9 Maintenance

The last ten trips and alarms shall be stored in two registers that may be consulted locally (date and time, type of fault or alarm).

Maintenance indicators shall be displayable on request on the front panel:

- Contact wear
- Operations counter

8.4.10 Communication option

On option Air circuit breakers shall be capable of communicating the following data via a bus:

- Circuit-breaker status (open / closed, connected / disconnected / test, tripped on a fault, ready to close)
- Control-unit settings
- Tripping causes
- The measurements processed by the control unit: current, voltage, frequency, power, power quality

It shall be possible to remotely control the circuit breaker.

It shall be possible to remotely modify circuit-breaker settings:

- Settings within the range defined by the switches on the front panel of the control unit
- Settings of the protection functions and the alarms

Communications functions shall be independent of the control unit.

9.0 Moulded Case Circuit Breakers (MCCB)

9.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 60255 -series / BS EN IEC 60255 -series / BS IEC/IEEE 60255 -series	Measuring relays and protection equipment
BS EN 60664-1	Insulation coordination for equipment within low-voltage supply systems. Principles, requirements and tests
BS EN 60947 -series	Low Voltage switchgear and control gear
BS EN 61000-4	Electromagnetic compatibility (EMC). Testing and measurement techniques. Radiated fields in close proximity
BS EN ISO 14001	Environmental management systems. Requirements with guidance for use
PD ISO/TR 14062	Environmental management. Integrating environmental aspects into product design and development

9.2 General

Moulded-Case Circuit Breakers (MCCB) shall comply with the relevant parts of BS EN 60947:

- They shall be of category A with a rated service breaking capacity (ICS) equal to 100% of the ultimate breaking capacity (ICU) on all the operational voltage range for the ratings more than 100 A
- They shall have a rated operational voltage of 690 V AC (50/60 Hz)
- They shall have a rated insulation voltage of 750 V AC (50/60 Hz)
- They shall be suitable for isolation, as defined by IEC 60947-1 and -2, clause 7-27 for overvoltage category IV for a rated insulation voltage up to 690 V according to BS EN 60664-1

Production site organisation shall operate quality control and environmental management systems, assessed by an independent certified auditing body, to BS EN ISO 9002 and BS EN ISO 14001.

MCCBs shall be designed with the environment in mind, in line with PD ISO/TR 14062. Materials shall be of halogen free type. They shall be supplied in recyclable packing complying with European Directives.

The manufacturer shall implement non-polluting production processes that do not make use of chlorofluorocarbons, chlorinated hydrocarbons, ink for cardboard markings, etc.

MCCBs shall be available in fixed or plug-in/withdraw able versions as well as in 3-pole and 4-pole versions. For plug-in/withdraw able versions, a safety trip shall provide advanced opening to prevent connection and disconnection of a closed circuit breaker

MCCBs shall provide double or reinforced insulation (according to BS EN 60664-1) between the front and internal power circuits.

9.3 Construction, Operation, Environment

For maximum safety, the power contacts shall be insulated in an enclosure made of a thermosetting material from other functions such as the operating mechanism, the case, the trip unit and auxiliaries

The operating mechanism of MCCBs shall be of the quick-make, quick-break type with fault tripping overriding manual operation. All poles shall operate simultaneously for circuit breaker opening, closing and tripping.

MCCBs shall be actuated by a toggle or handle that clearly indicates the three positions – ON, OFF and TRIPPED.

In order to ensure suitability for isolation complying with BS EN 60947-2 clause 7-27:

- The operating mechanism shall be designed such that the toggle or handle can only be in OFF position (O) if the power contacts are all actually separated,
- In OFF position, the toggle or handle shall indicate the isolation position.

Isolation shall be provided by a double break on the main circuit.

MCCBs shall be able to receive a device for locking in the "isolated" position, with up to 3 padlocks.

MCCBs shall be equipped with a "push to trip" button in front to test operation and the opening of the poles.

MCCB rating, "push to trip" button, outgoing circuit identification and contact position indication must be clearly visible and accessible from the front, through the front panel or the door of the switchboard.

9.4 Current Limiting, Discrimination, Endurance

MCCBs shall be capable of greatly limiting currents. For short-circuits, the maximum thermal stress I^2t shall be limited to:

MAXIMUM THERMAL STRESS	RATINGS
$1 \times 10^6 \text{ A}^2\text{s}$	for ratings up to 250 A
$5 \times 10^6 \text{ A}^2\text{s}$	for ratings between 400 A and 630 A

These characteristics will allow high cascading performance with moulded-case or miniature circuit-breakers downstream.

MCCBs shall comprise a device, designed to trip the circuit-breaker in the event of high-value short-circuit currents. This device shall be independent of the thermal-magnetic or electronic trip unit.

MCCBs, the current ratings of which are identical with the ratings of their trip units, shall ensure discrimination for any fault current up to at least 35 kA rms, with any downstream circuit-breaker having a current rating less or equal to 0.4 times that of the upstream circuit-breaker.

The electrical endurance of MCCBs, as defined by BS EN 60947-2, shall be at least equal to 3 times the minimum required by the standard.

9.5 Auxiliaries and Accessories

It shall be possible to equip MCCBs with a motor mechanism for electrically controlled operation. An "auto/manual" switch in front shall, when set to the "manual" position, lock out electrical control; remote indication of "manual" or "auto" mode shall be possible.

Closing shall take place in less than 80 ms.

Following tripping due to electrical faults (overload, short-circuit, earth fault), remote reset shall be inhibited. It shall however be possible if opening was initiated by a voltage release. The operating mechanism shall be of the stored-energy type only.

The addition of a motor mechanism or a rotary handle shall in no way affect circuit breaker characteristics:

- Only three stable tripping mechanism positions (ON, OFF and TRIPPED) shall be possible with the motor mechanism
- Suitability for isolation shall be provided by positive contact indication (ON and OFF) in front of the motor mechanism module

MCCBs shall be designed to enable safe on-site installation of auxiliaries such as voltage releases (shunt and undervoltage releases) and indication switches as follows:

- They shall be separated from power circuits
- All electrical auxiliaries shall be of the snap-in type and fitted with terminal blocks
- All auxiliaries shall be common for the entire range
- Auxiliary function and terminals shall be permanently engraved on the case of the circuit breaker and the auxiliary itself
- The addition of auxiliaries shall not increase the volume of the circuit breaker

The addition of a motor mechanism module or a rotary handle, etc., shall not mask or block device settings.

It shall be possible to assemble earth fault protection moulded-case circuit breakers by adding a residual current device (RCD) directly to the circuit breaker case. The resulting device shall:

- Comply with Annex B of BS EN 60947-2
- Be immunised against nuisance tripping as per BS EN 60255 / BS EN IEC 60255 / BS IEC/IEEE 60255 and BS EN 61000-4
- Be capable of working normally down to -25 °C ambient temperature
- Operate without an auxiliary power supply, i.e. it shall be capable of operating normally on any 2-phase or 3-phase power network with a voltage between 200 V and 440 V, and of tripping the circuit-breaker even in the event of voltage dips down to 80 V.

It shall be possible to equip MCCBs with devices indicating faults without tripping the circuit breaker.

9.6 Protection Functions

9.6.1 General recommendations

MCCBs with ratings up to 250 A shall be equipped with trip units of either of two fully interchangeable types:

- Thermal-magnetic (thermal for overload protection and magnetic for short-circuit protection)
- Electronic

MCCBs with ratings over 250 A shall be equipped with electronic trip units.

Electronic and thermal-magnetic trip units shall be adjustable and it shall be possible to fit lead seals to prevent unauthorised access to the settings.

Electronic trip units shall comply with Annex F of BS EN 60947-2 (measurement of RMS current values, electromagnetic compatibility, etc.).

Protection settings shall apply to all circuit breaker poles.

The trip units shall not augment overall circuit breaker volume.

All electronic components shall withstand temperatures up to 125°C.

9.6.2 Thermal-magnetic trip units (up to 250 A) - characteristics:

- Adjustable thermal protection,
- Fixed magnetic protection for current ratings up to 200 A
- Adjustable (from 5 to 10 times the current rating) for current ratings greater than 200 A

It shall be possible to ensure neutral protection. The tripping threshold shall be equal to that of the phases, or to a reduced value (generally half of that of the phases).

9.6.3 Electronic trip units (up to 250 A) – Characteristics:

- Long-time protection (LT)
Selectable I_r threshold with forty-eight settings from 40 to 100 % of the trip unit rating
- Short time protection (ST)
 I_m threshold shall be adjustable from 2 to 10 times the thermal setting I_r and the time delay shall be fixed at 40 ms.
- Instantaneous protection
The threshold shall be fixed (between 12 and 19 times I_n , depending on the rating).
- Four-pole devices shall be equipped for neutral protection:
 - a. As standard with a 3-position setting
Neutral not protected - neutral tripping threshold equal to half the phase value, - neutral threshold equal to the phase value
 - b. If required by harmonic 3 neutral current circulation with a specific 3-position setting
Neutral not protected - neutral tripping threshold equal to 0,8 times the phase value, - neutral threshold equal to 1,6 times the phase value (Oversized Neutral setting up to avoid tripping nuisances due to the natural Harmonic currents circulation in the Neutral conductor)
- Load Monitoring Function
The following monitoring functions shall be integral parts of electronic trip units:
 - a. LED for load indication, lighted above 95 % of I_r , flashing above 105 % of I_r
 - b. A test connector shall be installed for checks on electronic and tripping mechanism operation using an external device
- Communication Options
It shall be possible to install a specific module that can provide the data transmission via a BUS, in particular all the trip unit settings, current measurements for each phase, tripping causes, circuit breaker status.

Software that allows these data to be analysed on PC shall be provided by the manufacturer

9.6.4 Electronic trip units (above 400 A and greater) – Characteristics:

- Short-time protection:

Selectable I_r threshold with thirty-two settings from 40% to 100% of the trip unit rating and adjustable time delay.

The breaking threshold shall be at $1.2 I_r$ and the no-breaking threshold after 2 h at $1.05 I_r$.

- Short time protection (ST):
 I_m threshold shall be adjustable from 2 to 10 times the thermal setting I_r and the time delay shall be selectable among 3 values, with or without the constant I^2t function.
- Instantaneous protection threshold adjustable from 1.5 to 11 times I_n .
- Thermal memory
 In the event of repeated overloads, the electronic trip unit shall optimise protection of cables and downstream devices by memorising temperature variations.
- Four-pole devices shall be equipped for neutral protection:
 - a. As standard with a 3-position setting
 Neutral not protected - neutral tripping threshold equal to half the phase value - neutral threshold equal to the phase value
 - b. If required by harmonic 3 neutral current circulation with a specific 3-position setting
 Neutral not protected - neutral tripping threshold equal to 0,8 times the phase value - neutral threshold equal to 1,6 times the phase value (Oversized Neutral setting up to avoid tripping nuisances due to the natural Harmonic currents circulation in the Neutral conductor)
- Load Monitoring Function
 A load monitoring function shall be an integral part of universal trip units, indicating four load levels (60 %, 75 %, 90 % and 105 %) by LEDs, (flashing LED for 105 %)
- Options
 It shall be possible to install all options for the electronic trip unit:
 - a. High-threshold earth-fault protection,
 - b. Load monitoring with adjustable threshold using a changeover switch,
 - c. LEDs in front to indicate the cause of tripping (long time, short time, instantaneous, earth fault if requested),
 - d. Data transmission via a BUS, in particular all the trip unit settings, current measurements for each phase, tripping causes, circuit breaker status.

It shall be possible to install a specific module that can provide the data transmission via a BUS, in particular all the trip unit settings, current measurements for each phase, tripping causes, circuit breaker status.

Software that allows these data to be analysed on PC shall be provided by the manufacturer.

10.0 Vacuum Circuit Breakers

10.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 60255 -series / BS EN IEC 60255 -series / BS IEC/IEEE 60255 -series	Measurement relays and protection equipment
BS EN 60282 v -series	High voltage current limiting fuses
BS EN 60947 series	Low Voltage switchgear and control gear
BS EN 61869 -series / BS EN IEC 61869 -series / BS IEC 61869 -series	Instrument transformers
BS EN 62271 series BS EN IEC 62271 -series	High-voltage switchgear and controlgear
PD IEC/TR 60787	Application guide for the selection of high-voltage current-limiting fuse-links for transformer circuits

10.2 General

The vacuum type circuit breaker shall conform to the above codes and standards and incorporate:

- 3 vacuum interrupters (breaking)
- An electromagnetic control unit which can be of
 - magnetic latching type
 - mechanical latching type
- Upstream and downstream connection terminals for the power circuit
- Mechanical contactor locking in the open position in order to avoid racking out or racking in with the contacts closed
- 3 HRC fuses with a striker and auxiliary contacts to trip the contactor
- An indicator on the front panel to show the contactor position
- A switching operation counter
- Auxiliary contacts
- Interchangeable with other contactors in the range

The rated voltage shall be minimum 12 kV for an 11 kV system and operate at 50 Hz.

11.0 Fuse Switch Unit, Switch fuses, Changeover Switches and Switch Disconnecter

11.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 60269-series / BS HD 60269-series / BS 88-series	Low voltage fuses – General and supplementary requirements for fuses for use by authorised persons
BS EN 60947-1	Low Voltage switchgear and control gear

11.2 General

All switchgear shall be rated for operation at a voltage of at least 500 V AC. It shall be installed where specified and detailed on the distribution diagram. The units shall be metal clad unless otherwise specified.

All switchgear shall be provided with suitable locks for padlocking the switches in the 'OFF' position. The cover shall be interlocked with the operating mechanism to prevent it from being opened in the 'ON' position. This interlocking shall also prevent the switch from being closed with the cover open unless the mechanism is operated by an authorised person for examination and maintenance purposes.

The cover shall be gasketed to prevent ingress of dust and grit. If the unit is located in a damp or moist area, a weatherproof unit should be utilised.

The switch action mechanism shall be of the parallel operation double break type, having cartridge fuses mounted on an insulated bar forming the plate assembly for fused switches and shall be certified by an Intertek ASTA or BEAB approved laboratory to adequately meet all required duties as specified.

All units shall be supplied complete with the appropriate HRC fuse units or links as necessary.

A switch disconnecter shall be located adjacent to all mechanical plant including fans, pumps, burners etc. During the construction works all switchgear including switchboards, distribution boards, switch disconnectors etc. shall be adequately protected to prevent mechanical damage. At the end of the contract, all switchgear shall be cleaned down and any damaged metal services shall be painted to match the existing finish.

Each switch room shall be fitted with an instruction notice giving details of first aid treatment for electric shock.

The operating mechanism of the quick make and break pattern shall be controlled by powerful springs which shall be in tension only during the operation of the switch. The blades shall enter contact clips of heavy gauge copper shrouded with insulated shield which also protect the cable terminals. All current carrying components shall be electro tinned and ferrous parts shall be rust proofed.

The end plates shall be removable for drilling for conduit or cable entry. Units will be supplied with spreader boxes where necessary.

11.3 Fuses for Fused-Switch Units and Switchfuses

All fuses in switchgear shall be HRC fuses sized as specified or as detailed on the drawings.

They shall be certified by an Intertek ASTA or BEAB approved laboratory for compliance with relevant parts of BS EN 60269 / BS HD 60269 / BS 88, with a Category of Duty 440 AC 5 Class Q1.

12.0 Distribution Boards

12.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671/A1	Requirements for Electrical Installations
BS EN 60269-1, BS 88-1, BS HD 60269-2, BS 88-2	Low voltage fuses – General and supplementary requirements for fuses for use by authorised persons
BS EN 60947	Low-Voltage switchgear and controlgear. Circuit-breakers
BS EN 61082-1	Preparation of documents used in electrotechnology.
BS EN 61439-1	Low-voltage switchgear and controlgear assemblies. General rules.
BS EN 61439-2	Low-voltage switchgear and controlgear assemblies. Power switchgear and controlgear assemblies.
BS EN 61439-3	Low-voltage switchgear and controlgear assemblies. Distribution boards intended to be operated by ordinary persons (DBO)
BS EN IEC/IEEE 82079-1	Explosive Preparation of information for use of products.

12.2 General

All distribution boards, MCB's, fuses and isolators shall be of one manufacturer for the whole of the works.

All distribution boards, unless stated otherwise, shall be miniature circuit breaker distribution boards and shall be surface or flush type as specified. The sizes shall be as detailed on the drawings or in the schedules. Facilities for local isolation of the distribution boards shall be provided.

Where surface mounted units are specified for generally flush areas of the installation all conductors shall terminate behind the board in an adaptable box. For surface mounting, trunking shall be fixed between the board and ceiling level, or conduits shall be run directly into the board. Earth continuity of the system component parts upon completion shall afford low impedance and shall be tested in accordance with the current edition of BS 7671/A1.

All distribution boards shall be metal clad complete with lockable covers and hinged lids, which, together with the board itself, shall, when installed, afford a minimum ingress protection rating of IP41.

Rewireable type fuse distribution boards shall not be permitted.

12.3 Miniature Circuit Breaker Distribution Boards

All distribution boards shall be fitted with printed schedules in accordance with BS EN 61082-1 and BS EN IEC/IEEE 82079-1, defining all outgoing circuits, references, cable types and equipment served. The schedules shall be enclosed within a plastic sheath securely fixed to the distribution board.

MCB distribution boards shall comply with BS EN 61439-3.

The enclosure shall be provided with detachable gland plates, which shall be reversible and interchangeable from top to bottom.

All screws and nuts used in the construction of the enclosure shall be fitted with shake proof washers and care taken to ensure efficient earth continuity. An external earthing terminal shall be fitted and be connected to the integral earth bar.

The blanks shall be so spaced to obviate the necessity for insulating barriers, but protection shall be provided by means of insulating shields ensuring protection against accidental contact to at least IP2X or IPXXB with enclosure panels/covers removed and at least IP4X with enclosure panels/covers in place.

Bus-bars shall be of high conductivity hard drawn copper conductors connected to the MCB contacts by means of screws or bolts with sprung washers, unless plug in type MCB's are specified.

An integral main isolating switch unit shall be provided, unless otherwise specified, to isolate incoming live and neutral main cables from the bus-bars. The isolator switch shall be rated at 500 V and be of the quick make and break pattern with positive action. Outgoing conductors to the bus-bars shall be high conductivity hard drawn copper rods.

Isolating switches shall be selected in accordance with the current edition of BS 7671 and shall be capable of carrying their full rated load continuously and shall 'make' or 'break' their full rated load without undue burning of the contacts.

The isolating distances between contacts when in the open position shall not be less than those specified for isolators in the relevant parts of BS EN 60947.

Neutral bars shall be of the same size as the main bus-bars and shall have two screw terminals per way for ratings of 30 A or over. Single screw connections will be allowed for capacities up to 30 A. The neutral bars shall have one terminal for each possible single-phase connection within the board and connection of conductors to the neutral bar shall be made in the same order as the MCB ways.

All distribution boards shall also contain internal earthing bars similar to the neutral bars detailed above, with one terminal for each possible single-phase connection within the board. Earthing conductors shall be connected in the manner described for neutral conductors.

All terminals shall be readily accessible from the front of the distribution board.

Distribution boards shall be supplied complete with all outgoing MCB's, RCD's etc. as specified in the schedule and also be supplied with blank ways as necessary.

Unless otherwise detailed the spare capacity available upon completion shall be 25%.

12.4 Fused Distribution Boards

All fuse boards shall be rated for 500 V operation and meet the requirements of relevant parts of BS EN 61439.

The details specified in the previous sub-clause "Miniature Circuit Breaker Distribution Boards" shall apply as far as cabinet and cover construction, cabling arrangements, bus-bars, neutral bars, earthing and isolating switches are concerned.

Fuse carriers and bases shall be manufactured from high quality or phenolic moulded construction. Fuse contacts shall be designed to give adequate and even pressure between the base contacts and carrier clips, by means of phosphor bronze springs, and shall be of such cross section as to be capable of carrying the full load rating continuously without undue temperature rise.

Fuse banks shall be fitted to detachable frames with robust locking plates provided to secure the frame rigidly in the fixed position.

Fuse banks shall be so spaced as to obviate the necessity for insulating barriers, but protection shall be provided by means of insulating shields to prevent accidental contact with the main bus-bars and connections.

All fuses shall be of the HRC cartridge type, certified by an Intertek ASTA or BEAB approved laboratory, for compliance with relevant parts of BS EN 60269 / BS HD 60269 / BS 88, with a Category of Duty 440 AC 5 Class Q1.

13.0 Cartridge Fuses

13.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 1362	Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs).
BS 1363-2/BS 1363-4	13A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets
BS 2950	Specifications. Cartridge fuse links for telecommunications and light electrical apparatus.
BS 5733	General requirements for electrical accessories.
BS 646	Specification, Cartridge fuse links (rated up to 5 Amperes) for AC and DC service.
BS EN 60127-2	Miniature fuses. Cartridge fuse-links
BS HD 60269-3, BS 88-3	Low-voltage fuses. Supplementary requirements for fuses for use by unskilled persons (fuses mainly for household and similar applications). Examples of standardized systems of fuses A to F

13.2 General

All fuses installed within 13 A plugs and fused connection units to BS 1363-2 and BS 1363-4, and clock connectors to BS 5733, shall be certified in accordance with the Plugs and Sockets (Safety) Regulations for compliance with BS 1362. Fuses in shaver adaptors and dry-area shaver outlets to BS 4573 shall be certified by Intertek ASTA or a BEAB approved laboratory for compliance with BS 646.

All equipment connected under this Contract which is locally fused shall have fitted fuses with characteristics which are recommended by the manufacturer of the equipment.

If any appliance or equipment suffers due to incorrect fusing of the appliance, this shall be repaired or replaced at no extra cost to the Contract.

14.0 Protective devices for Distribution Boards, Consumer Units and Similar Service

14.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 60898-2	Electrical accessories. Circuit-breakers for overcurrent protection for household and similar installations. Circuit-breakers for a.c and d.c operation.
BS EN 60947-2	Low voltage switchgear and controlgear. Circuit breakers
BS EN 61008-1	Residual current operated circuit-breakers without integral overcurrent protection for household and similar uses (RCCBs) General rules
BS EN 61009-1	Electrical accessories. Residual current operated circuit-breakers with integral overcurrent protection for household and similar uses (RCBOs) General rules
BS EN 61439	Low-voltage switchgear and controlgear assemblies.
BS EN 62423	Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses
BS EN 62606	General requirements for arc fault detection devices
BS IEC 62955	Residual direct current detecting device (RDC-DD) to be used for mode 3 charging of electric vehicles

14.2 General

The protective devices covered under this section include the following:

- Miniature Circuit Breakers (MCB)
- Residual current operated circuit-breakers without integral overcurrent protection (RCCB)
- Residual current operated circuit-breakers with integral overcurrent protection (RCBOs)
- Residual direct current detecting device (RDC-DD)
- Arc fault detection devices (AFDD's)

14.2.1 Contacts and operating mechanisms

All protective devices shall have movements which are positive in both directions (make and break) so as to enable units to be closed decisively by the operation of the handle, and to be able to be opened under any circumstances. The handles shall not be able to assume the 'OFF' position unless the contacts are definitely separated, to safeguard against false indication.

The operating mechanism of protective devices shall be trip free to make it impossible for the operator to hold the protective device breaking mechanism in the closed position under faulty conditions. The operation mechanism and arc chambers of the circuit breaker shall be separated from the terminals and fixing screws.

Identification shall be readily discernible as viewed from the front of the MCB board with automatic and clear signal identification for both 'ON' and 'OFF' positions.

The protective devices shall provide isolation.

14.2.2 Number of Switched Poles in Protective Devices

Where indicated on the drawings and schedules:

- all single-phase protective devices shall be 2-pole incorporating a switched neutral
- all three-phase protective devices shall be 4-pole to provide a switched neutral

14.2.3 Selection, selectivity, and coordination of protective devices for lighting circuits

Selection, coordination and selectivity of protective devices for, and upstream of, a lighting circuit shall be selected taking into account the transient starting, inrush, and continuous operational load, and the steady-state, transient and inrush residual currents, of lighting controllers, ballasts and drivers, in accordance with the recommendation of the lighting manufacturer and lighting controls manufacturer.

14.3 Miniature Circuit Breakers (MCB's)

MCB's shall comply with a suitable harmonized standard such as BS EN 60898-2 or BS EN 60947-2.

Miniature circuit breakers protecting two or three phase circuits shall be ganged type. Individual MCB's shall not be allowed. Multi-phase circuit breakers shall not be employed on single-phase circuits.

All MCB's shall be rated at 500 V and have electrical characteristics coordinated for the assembly they are selected to operate within, including, but not limited to, prospective short circuit current ratings. Devices shall be rated so that selectivity is maintained upstream and downstream according to BS 7671.

All MCBS shall have a fault current making and breaking capacity that exceeds the prospective fault current of the distribution board in which the MCBs are installed. An exception is permitted only where the MCB is part of a UK type-tested assembly, covered by the assembly manufacturer's type test, as described in Annex ZB of BS EN 61439-3, and the assembly is protected by a fuse (or service cutout) with a nominal current rating of 100 A or less, complying with BS 88-3.

14.4 Residual Current Circuit Breakers with Integral Overcurrent Protection (RCBO's)

RCBO's shall comply with suitable harmonized standards such as BS EN 61009-1 or relevant parts of BS EN 60947-2 plus BS EN 61008-1 or BS EN 62423.

RCBO's shall have a residual current rating suited for the functionality required. The Type of RCD (Type A, Type B or Type F) shall be selected taking into account downstream residual currents expected, in accordance with BS 7671. Type AC RCBO's shall not be used.

All RCBO's shall have electrical characteristics coordinated for the assembly they are selected to operate within, including, but not limited to, prospective short circuit current ratings. Devices shall be rated so that selectivity is maintained upstream and downstream, and nuisance tripping avoided, according to BS 7671.

All RCBO's shall have a fault current making and breaking capacity that exceeds the prospective fault current of the distribution board in which the RCBO's are installed. An exception is permitted only where the RCBO is

part of a UK type-tested assembly, covered by the assembly manufacturer's type test, as described in Annex ZB of BS EN 61439-2-pole3, and the assembly is protected by a fuse (or service cutout) with a nominal current rating of 100 A or less, complying with BS 88-3.

14.5 Residual Current Circuit Breakers (RCCB's)

RCCB's shall comply with suitable harmonized standards such as BS EN 61008-1 or BS EN 62423.

RCCB's shall have a residual current rating suited for the functionality required. The residual fault current detection Type (Type A, Type B or Type F) shall be selected taking into account downstream residual currents expected, in accordance with BS 7671. Type AC RCCB's shall not be used.

All RCCB's shall have electrical characteristics coordinated for the assembly they are selected to operate within, including, but not limited to, prospective short circuit current ratings. Devices shall be rated so that selectivity is maintained upstream and downstream, and nuisance tripping avoided, according to BS 7671.

14.6 Arc fault detection devices (AFDD's)

Arc fault detection devices shall be provided for all single-phase AC final circuits with a nominal voltage not exceeding 230 V, rated between 6 A and 63 A inclusive:

- in premises with sleeping accommodation, including dwellings
- in buildings with a risk of fire due to its construction from combustible materials
- in buildings in which combustible materials are stored
- in buildings in which irreplaceable goods are stored
- where otherwise indicated in the design drawings or the particular specification

AFDDs shall be fitted at the final circuit distribution board, or consumer unit, supplying the circuit.

AFDDs shall not be provided for the following types of circuits, unless otherwise specified or approved by the Engineer:

- Medical IT systems in medical locations classified as Group 1 or Group2 in accordance with BS 7671.
- Circuits of safety services.

AFDD's shall comply with BS EN 62606.

Where AFDD's are contained in units that combine with other functions, such as overcurrent protection (MCB), residual current protection (RCCB), or combined residual and overcurrent protection (RCBO), the AFDD shall additionally comply with the relevant harmonized standard for those other functions.

14.7 Residual Direct Current Disconnecting Devices (RDC-DD's)

RDC-DD's shall comply with BS IEC 62955.

15.0 Labelling and Engraving

15.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671/A1	Requirements for electrical installations
BS EN 61082-1	Preparation of documents used in electrotechnology. Rules
BS EN 81346-1	Industrial systems, installations and equipment and industrial product. Structuring principles and reference designations. Basic rules
BS EN IEC/IEEE 82079-1	Preparation of information for use (instructions for use) of products. Principles and general requirements
BS EN ISO 7010	Graphical symbols. Safety colours and safety signs. Registered safety signs View details
BS ISO 3864	Safety colours and safety signs

15.2 General

All equipment shall be labelled to accurately define its reference and use.

All information and instruction notices and labels shall comply with BS EN 61082-1, BS EN 82079-1 and, where appropriate, BS EN 81346-1.

All warning notices and other safety signs shall comply with BS ISO 3864, BS EN ISO 7010, and BS 82079-1.

15.3 Labelling

Each item of electrical equipment including fused switch units, switch fuses, switches, bus-bar chambers, distribution boards and all other items of equipment shall be identified in accordance with Part 5 of the current edition of BS7671 and shall have securely fitted, in accordance with Clause 1.23; externally a white Traffolyte information label engraved with black letters at least 10 mm high detailing as a minimum the:

- a) Function of the equipment
- b) Reference number
- c) Fuse or breaker size type

Examples: - Lift No 1 Fuse switch DBL1/1 fused at 60 A TP&N.

The label shall identify whether or not the neutral pole is switched.

L1, L2, L3 thermosetting plastic phase buttons shall be fixed inside all switchgear and distribution boards to indicate to which phase of the supply the various circuits are connected. The designation shall comply with Part 5 of the current edition of BS7671.

Flexible Traffolyte or LSZH, thermal transfer, thermal embossed durable identification labels shall be provided, and tie wrapped at both ends of all sub main cables. The labels shall clearly state source of supply, purpose of sub main cable, size and number of conductors and type of cable.

Each distribution board shall be fitted internally with a TYPE WRITTEN list, prepared in accordance with BS EN 61082-1 and BS EN IEC/IEEE 82079-1, giving details of all MCB or fuse ratings, earth leakage rating (where applicable), supply phase(s), equipment serviced and size and type of all circuit conductors.

A draft copy of the typed chart shall be made available to the engineer for comment. The final version shall incorporate the engineer's comments where necessary onto the chart.

Each list shall be mounted in a document pouch formed from 0.5mm. thick clear non-flammable material.

The envelope shall be open at one end and fitted to the inside of the distribution board with 5mm. diameter rivets passing through eyelets in the envelope.

An additional TYPED copy of each circuit card shall be incorporated in the operation and maintenance manuals.

Each TP or TP&N item of switchgear shall have fitted on the cover a white Traffolyte warning label complying with BS ISO 3864 and BS EN IEC/IEEE 82079-1 with 'Caution – 400 VOLTS' engraved in 10 mm high black-on-yellow lettering.

With the exception of rating plates and similar product labelling information required of harmonized standards, no manufacturers' or installers' name plates whatsoever shall appear on the work unless written permission is obtained from the Engineer.

15.3.1 Materials

Use materials for labels and notices with a predicted life equal to or greater than the design life of the electrical cables, plant, equipment or installation to which it refers.

15.3.2 Fixing

The labels shall be fixed in position by the use of mechanical screws, setscrews or rivets. (The use of adhesive alone will not be acceptable for enclosures, but, where required, adhesive labels, of a type approved by the Engineer, may, at the Engineer's discretion, be applied to discrete products to be mounted on desks etc., for example telephones and desktop ICT equipment.)

15.3.3 Arrangement

Obtain approval prior to manufacture, with regard to style, colour, lettering, size and position of all labels and notices.

Provide sample showing style, colour, lettering and size, for approval.

15.3.4 Size of Lettering and Symbols for Labels, Notices and Safety Signs

Ensure that all lettering and symbols comply with British and European legislation. Ensure labels and notices of adequate size for the lettering and symbols required and allow a minimum margin around all lettering of one line space vertically and two-letter spacing horizontally.

Text Font : Arial

Text Size : 5mm minimum high letters. Smaller sizes complying with BS EN IEC/IEEE 82079-1 may be used, subject to approval by the Engineer, for labels required on very small products with label size < 10 cm²

Symbol Size : 10 mm minimum height and width for safety signs. 5 mm minimum height and width for general symbols. Smaller sizes of general symbols complying with BS EN IEC/IEEE 82079-1, may be used, subject to approval by the Engineer, for labels required on very small products with label size < 10 cm²

15.3.5 Safety Signs and Warning Notices

Provide all safety signs and warning notices required by relevant standards including, but not limited to, BS 7671.

Label all electrical plant and equipment using safety sign complying with British and European legislation where voltages above ELV exist.

Provide with each safety sign supplementary or text signs as required.

Labels for entrances to each substation and switchroom shall be provided, giving details of the following:

- Name of the substation or switchroom
- The presence of medium and low voltages
- Administrative instructions for access
- Locations and method of contacting controlling authority
- Actions to be taken in an emergency

15.3.6 Plant and Equipment Labels

Fit durable and indelible labels on all items of plant, equipment, switches, etc., include the following information: service controlled, circuit reference, voltage, type of supply and phase etc., circuit protection type and rating.

15.4 Engraving

Allow for engraving all switched fused connection units, double pole switch accessories and any other accessories which are supplying fixed equipment.

The accessory plate shall be engraved in either black or red, capital letters, 5mm. high, detailing the appliance or equipment being supplied by the accessory e.g.

'EXTRACT FAN', 'FAN CONVECTOR' etc.

16.0 Cable Trunking

16.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 476-12	Fire tests on building materials and structures. Method of test for ignitability of products by direct flame impingement.
BS 7671	Requirements for Electrical Installations
BS EN 10346	Continuously hot-dip coated steel flat products for cold forming.
BS EN 50085-1	Cable trunking systems and cable ducting systems for electrical installations. General requirements
BS EN 50085-2-1	Cable trunking systems and cable ducting systems for electrical installations. Cable trunking systems and cable ducting systems intended for mounting on walls and ceilings.
BS EN 50085-2-2	Cable trunking systems and cable ducting systems for electrical installations. Particular requirements for cable trunking systems and cable ducting systems intended for mounting underfloor, flushfloor, or onfloor

16.2 General

Trunking shall only be installed in situations which will remain readily accessible throughout the life of the building. No cable trunking shall be installed behind a plastered ceiling or in other inaccessible situations.

The trunking layouts indicated on the drawings show the minimum requirement. Any additional trunkings deemed necessary shall be shown on the installation drawings prepared and submitted to the engineer for approval. The approval of any such additional trunkings will be at the discretion of the Engineer. Any additional cable trunking systems shown shall be at no extra cost to the contract as they will be in the place of conduits which should have been allowed to enclose the cabling systems.

Where cable trunking is installed within ceiling voids, the trunking shall be located as near as is practical to the rear of the ceiling grid whilst still allowing the removal of ceiling tiles or access panels. The cable trunking shall be run below other services including ductwork, pipework and public health services. The cable trunking system shall be independently supported by drop rods and support steel works from the structural soffit. Allow for the installation of all such steel works.

All trunking shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671.

16.3 Sheet Steel Cable Trunking

Steel cable trunking shall comply with relevant parts of BS EN 50085 Hot-Dip Pre-Galvanised to BS EN 10346. The trunking body will have a return edge on its opening side and the steel shall not be less than 1.4 mm thick.

The Engineer must be consulted as to precise details concerning trunking routes and applications.

All lengths of trunking shall be butt jointed and connected together by internally fitted couplings of sufficient width to provide a minimum bearing face of 25 mm to each section being joined on all three faces. The lengths shall be bolted together on site or welded at the factory. The coupling will be of the same material as the trunking body.

For trunking systems having a cross section area up to 5,650 mm², 4 No M4 cadmium plated steel screws will be utilised per coupling. For trunkings over 5,650 mm², 8 No similar screws will be utilised. The screws will either be terminated into pre-tapped fixed bushes, or into nuts and shake proof washers.

A tinned copper link shall be fitted across each trunking joint to ensure electrical continuity. The link may be fixed by 2 of the joint securing screws, one on each section of trunking.

Adequate provision shall be made to allow for expansion on all installed lengths of trunking.

All the pieces and bends shall be formed with similar means of connection and the inner radius area shall be such that cables will not be bent through a radius less than that prescribed in the current edition of BS 7671/A1. Only bends and tees of approved pattern will be accepted.

All fixing screws within the trunking shall be of the round head type.

The trunking shall have an overlapping well-fitted lid securely fixed to the trunking by approved means that will avoid damage to the cables. Self-trapping screws shall not be used. The lid will be removable throughout the entire length of the trunking system and be of the same material as the trunking body. The lid fixing centres shall not be greater than 450 mm and cadmium plated screws shall be used.

All necessary accessories including long sleeve couplings, end pieces, bends, sets, tees, reducers, branches, fillets, spin racks, cable retainers etc., shall be allowed for in the Tender, and shall be purpose made by the manufacturer. Fabrication on site will not be permitted.

Where a change in direction of a trunking run occurs, the deviation should be affected by a purpose made unit manufactured on similar lines to the bends and tee pieces described above. Where this is not practical, changes in direction shall be fabricated in a neat and workmanlike manner. All joints shall fit closely and gaps will not be permitted. When installed with covers in place, the trunking system shall provide ingress protection to at least IP4X to be suitable for containment of unsheathed cables in accordance with BS 7671.

All burrs and sharp edges shall be removed and no screw shall protrude into the trunking.

Trunking shall be firmly attached to its associated equipment either by bolted flanges or by male bushes and couplings.

Connections to metal clad switchgear, including distribution boards, switch disconnectors, switch fuses, bus bar chambers and main switchboards shall be direct bolted connections. A co-incident oval slot shall be cut into the item of switchgear and into the trunking system. A Paxolin, Tufnol, or similar insert shall be cut to fit between the switchgear and the trunking having a similar oval slot but reduced in size by 5mm all around. The size of the slot within the Paxolin/Tufnol will be sufficient to allow unrestricted space for the circuit conductors. The Paxolin/Tufnol insert shall be of a minimum of 5 mm thick and sharp corners produced from cutting shall be removed. A copper earth bonding tape shall be run between the item of switchgear and the trunking to ensure electrical continuity. The cross-sectional area of the tape shall be such to provide the same copper conductance of that provided by the steel trunking.

Where trunking is connected to equipment by means of flange connectors the entry into the equipment shall be of the same cross-section as the trunking.

When trunking does not terminate in equipment the otherwise open end shall be capped with a cover suitably bolted in position.

Where trunking contains voltages of different bands, and/or ICT cabling with cabling of other electrical services, the requisite number of separate compartments shall be provided to segregate the wiring. Compartment separators shall be metal unless otherwise approved by the Engineer. Where conduits are taken off such trunking they shall not pass through other compartments unless prior permission is obtained from the Engineer. The separation between compartments shall be maintained at all tees angles reducers etc. to ensure complete segregation is maintained.

Proprietary cross over sections shall be used wherever a cable from one dedicated compartment of the trunking is required to pass through another dedicated compartment. On no accounts shall any crossing of compartments be made without the consent of the engineer.

The entire trunking system shall be electrically and mechanically continuous throughout.

Where trunking is required to be recessed in the structure of the building the finished edge of the trunking is to be installed flush with the plaster work, the lid shall be of the overlapping type.

Trunking runs shall be so arranged that the lid or cover plate is always on the top or side and not underneath unless this cannot be avoided in which case the Engineer's permission shall be obtained.

Wherever trunking passes through walls vertical partitions etc., a fixed piece of trunking lid shall be fitted to the trunking extending 25mm either side of the wall. Care shall be taken to see that no orifice is left between the trunking and the building structure through which fire might spread. In addition, a suitable barrier of incombustible material shall be provided and fitted inside the trunking, in accordance with Part 5 of the current edition of BS 7671/A1.

On vertical runs of trunking internal incombustible barriers shall be fitted at a distance not greater than 5m, in accordance with Part 5 of the current edition of BS 7671/A1.

All vertical runs of trunking which pass through floors shall be fitted with fire barriers in accordance with Part 5 of the current edition of BS 7671/A1.

All trunking shall be fixed so as to drain off any condensed moisture.

Where under floor trunking is to be installed reference shall be made to subsequent Sections of the Specification. Steel under floor trunking shall be in accordance with BS EN 50085-2-2.

All necessary trunking support work, hangers, brackets and fixing requirements shall be provided. The fixings shall be in accordance with the manufacturer's recommendations and shall not be spaced greater than 1.2 m.

Earth links of the appropriate size and type shall be installed at every joint, coupling, manufactured bend, tee, etc., throughout the entire trunking system. Notwithstanding the above, separate circuit protective conductors shall be run with every circuit.

In cases where sheet steel trunking is installed on wooden floor joists or similar applications, and there is a danger of movement, a flexible earth conductor shall be installed bonding all joints in the trunking. This shall be fitted in addition to the standard earth links.

Purpose made spring type cable retaining clips shall be fitted at one metre intervals unless trunking is installed with the cover on the top side.

Insulated cable support pins shall be fitted at intervals of 3 m in vertical runs of trunking to adequately support the enclosed cables.

The conductors of each separate circuit within the trunking system shall be taped together with insulating tape at intervals not exceeding 1.2 m. Identification sleeves shall be fitted at each junction or tapping point.

Cable trunking systems shall be sized to provide a minimum of 25% spare capacity for future cabling. This spare capacity shall be calculated in accordance with the space factor limitations as noted within the current edition of BS 7671/A1.

All paintwork that has been damaged or removed during the onsite erection of the system shall be treated in accordance with the manufacturer's recommendations upon completion of the system installation.

16.4 Insulated Cable Trunking

Insulated trunking shall only be used where an insulated conduit system is being installed unless specifically stated otherwise.

The trunking shall be adequately fixed at intervals not exceeding one metre. Fixing holes shall be slotted to allow any subsequent expansion due to temperature variations. Cable clips shall be fitted at each fixing point, in each compartment of the trunking, to comply with Regulation 521.10.202 of BS 7671.

Insulated trunking shall not be installed where ambient temperatures are expected to exceed + 60°C or fall below -5°C. Care shall be taken to ensure that the trunking is not deformed by fixings, this applies particularly when trunking is fixed to an uneven surface. Unobtrusive packing pieces shall be introduced in order that the trunking shall be securely fixed level and plumb without being deformed.

Insulated cable trunking shall be smooth inside and outside, free from imperfection and manufactured by an approved manufacturer.

Insulated cable trunking shall be of high impact resisting heavy gauge type fitted with well-fitting lids of an approved type and size or as indicated in the Particular Specification, Schedules, or Drawings.

Purpose made spring type cable retaining clips shall be fitted at one metre intervals unless trunking is installed with the cover on the top side.

Insulated cable support pins shall be fitted at intervals of 4 metres in vertical runs of trunking and at the top of the vertical trunking.

Internal fire barriers shall be fitted where vertical trunking passes through floors.

Overlapping cover plates shall be fitted where installed flush with the building fabric. The finished edge of the trunking shall finish flush with the finished surface.

Insulated trunking shall be fitted with manufacturer's standard tees, off-sets and other fittings where changes of direction occurs.

Where trunking terminates manufacturer's standard plates and flares shall be fitted to connect to items of equipment.

Joints shall be affected using the manufacturer's standard internal connectors and in accordance with the manufacturer's recommendations.

Installations shall be in accordance with the appropriate conditions covering the installations of insulated conduit.

Separate protective conductors shall be installed in the trunking.

All joints and fabricated bends etc. in insulated trunking shall be made in a neat and workmanlike manner and all joints in trunking and in trunking cover shall fit closely and be free from gaps to achieve a minimum ingress protection of IP4X when installed and covers in place, so that it is suitable for unsheathed cables in accordance with BS 7671. Additional fixing shall be provided to the building structure 50 mm either side of the joint.

Joints in the lid and trunking must not be allowed to coincide.

The manufacturer's recommendations regarding the installation of insulated trunking must be adhered to at all times.

All conduit entries shall be made by means of purpose made bushes and couplings or adaptors.

Proprietary cross over sections shall be used wherever a fire cable, extra low voltage cable or mains cable are required to pass through a dedicated compartment of the trunking. The Engineer shall be advised of all occurrences of cross overs at the time of installation.

17.0 Conduit Systems

17.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 4568/ BSEN 50086/ BS EN 61386 BS 4568-1	Specification for Steel Conduit and Fittings with Metric Thread of ISO Form for Electrical Installations - Part 1: Steel Conduit, Bends and Couplers
BS 4568-2	Specification for Steel Conduit and Fittings with Metric Threads of ISO Form for Electrical Installations Part 2: Fittings and Components
BS EN 61386-1	Conduit systems for cable management – General requirements
BS 4607-1	Non-metallic conduit fittings for electrical installations. Specification for rigid conduits, fittings and boxes of insulating material
BS 4607-5	Non-metallic conduit fittings for electrical installations. Specification for rigid conduits, fittings and boxes of insulating material.
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 10346	Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions
BS EN 60423	Conduit systems for cable management. Outside diameters of conduits for electrical installations and threads for conduits and fittings
BS EN 60529	Degrees of protection provided by enclosures
BS EN 61386-1	Conduit systems for cable management. General requirements
BS EN 61386-21	Conduit systems for cable management. Particular requirements. Rigid conduit systems
BS EN 61386-23	Conduit systems for cable management particular requirements flexible conduit systems.
BS EN 61386-24	Conduit systems for cable management. Particular requirements. Conduit systems buried underground
BS EN 61386-25	Conduit systems for cable management. Particular requirements. Conduit fixing devices
BS EN 61836-22	Conduit systems for cable management. Particular requirements. Pliable conduit systems

17.2 General

Conduits shall be installed to protect and enclose cables as required by the current edition of BS 7671, and when installed and all accessory, drawing and inspection covers are in place, afford a minimum BS EN 60529 ingress protection rating of IP4X to be suitable for containment of unsheathed cables.

The minimum conduit size used shall be 20 mm.

Conduits and conduit fittings and components shall be heavy gauge and shall be manufactured in accordance with BS 4568-1, BS 4568-2, BS EN / IEC 61386-1

Unless shown on the drawings or detailed within the specification, devise the conduit network for the installation in accordance with the current edition of BS 7671. All conduits shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671.

All bends formed in conduits shall be made in a conduit bending machine fitted with a former of the correct radii for each conduit size. The bends shall be made without altering the section of the conduit or opening the seams of the conduit. The inside radius of all bends shall exceed 3 times the external diameter of the conduit.

All conduits shall be secured in an efficient pipe vice whilst being cut, screwed and reamed.

Conduits shall be installed either vertically or horizontally and generally be installed in line or perpendicular to the building structure.

The whole of the conduit installation shall be co-ordinated with other services to be installed in the building or buildings, and routes shall be agreed with the Engineer prior to the commencement of the installation. Conduits shall be installed at least 250 mm from hot water pipes and at least 50 mm from other service pipes, cables and ducts.

Conductive conduits shall be bonded to other services in accordance with the requirements of the current edition of BS 7671.

Unless otherwise noted all conduits must be concealed, being run in roof spaces, behind suspended ceilings, under floors, within in situ cast concrete, or in cut/cast chases into walls. Surface run conduit installations will only be permitted at the discretion of the Engineer. All conduits that are to be concealed shall be inspected and tested prior to enclosure. Surface conduit work shall only be allowed where methods of construction preclude the concealment of the conduit and on fair faced brickwork or block work subject to approval to the Engineer.

Conduit runs shall be planned to obviate the need for draw in boxes, but where the use of such boxes is unavoidable, they shall be accessible at all times and be fitted with covers.

Conduit systems shall be complete and continuous throughout. Luminaires and other equipment bodies shall not be used for through wiring.

Where conduits cross expansion joints proprietary expansion couplings shall be utilised. Earth continuity shall be maintained by LSZH sheathed green-and-yellow copper conductors with minimum cross-sectional areas of 4 mm² connected to each side of the expansion joints by proprietary earth clamps.

Prior to the drawing of any cables the complete conduit system shall be swabbed to remove any debris or moisture.

Conduits shall be stored in dry conditions prior to installation. All conduits damaged mechanically or by oxidation will be rejected.

The installation of conduit boxes in floors shall generally be avoided but where it is essential it shall be agreed with the Engineer. The floor mounted boxes shall be fitted with brass covers recessed to accommodate the floor finish. The covers shall seal the box against the ingress of moisture.

Conduit boxes used for drawing in purposes shall be installed complete with well-fitting rubber gaskets unless detailed otherwise.

In a building which is being refurbished every expedient must be adopted to conceal conduits in floors and available roof spaces. Switch drops and other necessary and unavoidable runs of conduit across plastered walls and ceilings without accessible back space must be concealed unless specific instructions are issued in respect of a particular project to allow conduits on surfaces.

When conduits are specified as being installed on the surface the runs must be arranged to render the whole system as neat and inconspicuous as possible having regard to existing Architectural features. All vertical and horizontal runs must be plumbed and levelled respectively.

Particular care must be taken to obtain a symmetrical layout where conduits converge and run together near distribution centres. The distance between conduits shall be maintained through bends and sets and shall not noticeably vary.

All conduit runs must be designed to permit wiring to be readily installed after the complete erection of the conduits through the available draw-in, accessory and luminaire suspension boxes.

No conduit runs will be allowed to be laid underground in any circumstances whatsoever.

Cable drawing facilities shall be provided no greater than 6m apart for straight lengths of conduit installation and after every 2 right angle bends or equivalent sets.

In cases where it is necessary to install draw in boxes, where a number of circuits of the same voltage run together in the same direction, adaptable junction boxes of the required size to take all conduits shall be fixed in the run to facilitate the drawing-in of the cables instead of inserting a separate circular box in each individual run.

In all positions where the appearance of the conduit layout would be improved by the introduction of dummy lengths of conduit and in all cases where a more secure fixing for the suspension of fittings is considered necessary and would be obtained by continuing the conduits from their respective normal terminations, such dummy conduits and continuations must be included for and introduced.

Where surface mounted equipment (other than luminaires) is specified all concealed conduits shall be terminated in a conduit or an adaptable box installed recessed into the wall at every surface mounted equipment position. The recessed box shall in every case be completely covered by the surface mounted equipment. Provision shall be made in the back of the surface mounted equipment for the conveying of cables (including protective conductor) from the conduit system via a suitably bushed opening.

Any opening between the recessed box and the surface mounted equipment shall be closed when the surface mounted equipment is fixed, to prevent the ingress of dirt etc.

Where surface mounted luminaires are to be fixed to a concealed conduit system the boxes shall be circular. Screwed metal caps or plugs shall be used to protect the open ends of conduits and boxes. Special care shall be taken to prevent foreign matter entering the conduit. Cork plugs shall be used at temporary conduit terminations to prevent the ingress of foreign matter.

17.3 Steel Conduits

All metal conduits shall be new, heavy gauge, seam welded, steel tube screwed conduits complying with the relevant parts of BS EN 61386. All conduits shall be appropriately selected such that they are fully compatible with the local environmental conditions in which they are to be installed, and also for the surfaces that they are to be fixed to. Indoor conduits shall be class 2. Conduits located outside, in damp locations or where electronic equipment will be installed such as Data Centre's shall be Class 4 Hot-Dip Pre-Galvanised.

Any conduits and fittings which do not conform to specification or are damaged due to poor storage and handling on or off site shall be rejected and removed from site.

Circuits shall be segregated in accordance with the current edition of BS 7671. Ancillary services, extra low voltage circuits, ICT cabling and emergency lighting circuits shall in all cases be run in dedicated conduits.

Only circuit conductors originating from the same distribution board shall be run together in the same conduit/trunking system. Circuit conductors from different systems or from different distribution boards shall not be run in the same conduit system or conduit accessory box. All circuit conductors of a particular circuit shall be enclosed within the same conduit. A separate protective conductor shall be run in all cases.

No cables apart from draw wires shall be drawn into a conduit system until it is completely finished. No conduits shall be filled beyond the maximum capacities set out in the appropriate tables within the current edition of BS 7671/A1.

Unless detailed otherwise, only class 4 Hot-Dip Pre-Galvanised conduit shall be used in the plantrooms, where exposed surface mounted, or in external locations.

Fire alarm circuits and emergency lighting circuits shall not be contained within a conduit system unless otherwise specified.

Any conduit work rejected by the Engineer shall be replaced at no extra cost.

The manufacturer's threads applied to each length of conduit shall be reduced in length to conceal the thread in the conduit box fitting or accessory without protrusion and cleaned by means of conduit tap or die before installation. Each joint shall have however a minimum of 6 whole turns of thread.

17.4 Conduit Fittings

All conduit fittings shall be screwed or loop in malleable iron type fitted with covers secured by brass screws. Rectangular adaptable hot dip galvanised steel boxes may be used on multi-conduit runs.

Male and female bushes shall be brass and shall be manufactured to comply with relevant British or Harmonized standards. All screwed couplers, lock nuts and reducers shall be made of malleable iron.

All circular type boxes must be fitted with long screwed spout conduit entries with the screwed thread terminating within the spout and the edges of the internal orifice of the box rounded and smoothed to act as a bush, excepting adaptable steel rectangular boxes and loop in conduit boxes, in which case male bush and flanged coupling must be used for conduit connections.

At multi conduit junctions where standard conduit boxes are impractical to use, malleable cast iron adaptable boxes shall be utilised. The size of the box shall be determined upon the volume and type of cables being installed. The minimum box dimension shall be 150 x 150 x 50 mm deep, all boxes to be used shall be verified with the engineer at the earliest available opportunity. The boxes shall be complete with a malleable cast iron flush lid secured by 4 No M4 brass pan head screws.

Where such boxes are required on flush conduit systems, they shall be fitted with a 1.5mm galvanised steel lid which shall overlap the box by a minimum of 6mm on all sides.

In situations where more than 3 No 25mm conduits are required to terminate in one side of an adaptable box, the box size shall be increased accordingly.

In concealed installations boxes shall be fixed with the rims flush with the finished surfaces, but when for any reason whatever the rims are below the surface, suitable extension rings of the required depth shall be provided and installed to finish flush with the surrounding surfaces and with the lids of sufficient oversize (7.5mm minimum all round) to cover the junction between box and plaster.

In no case will the use of proprietary bends, sets, elbows, inspection elbows or tees be permitted, unless specifically allowed in writing by the Engineer to meet specific conditions.

17.5 Fixing of Conduits

All conduits must be firmly and rigidly fixed to be entirely without whip or movement. Spacer bar saddles or corrugated strap saddles must be used on the timbers in roof spaces and will be allowed when conduits are run on the underside of exposed unsealed floor or ceiling joists. Conduits shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671.

Pipe hooks or crampets will not be allowed for securing conduits.

The standard spacer bar galvanized or stainless steel saddle (single fixing base and two screw fixing top) shall be used for all conduits run on the surface of walls and ceilings etc., throughout the building, fixed at intervals of not more than 1.2 m. For insulated conduit systems, galvanized saddles shall be painted to match the finish of the conduit system.

Where surface conduits have been approved by the Engineer for use in kitchens or food preparation areas distance saddles shall be used.

Spacer bar saddles shall be fixed by a sheradised screw of minimum length 30 mm set into a fibre, white metal or similar plug of the correct size.

Where the conduit system is the sole support of the luminaires via conduit boxes, additional saddles disposed symmetrically about and near to the point of suspension must be introduced for security of fixing.

Galvanised, sheradised or cadmium plated screws shall be used in all cases where galvanised conduit is installed.

When conduits are required to be run on shuttering, prior to the laying of concrete in situ, additional security must be provided near to every box and at intervals of not more than 1.2 m by the introduction of short lengths of steel wire, of not less than 2 mm diameter twisted around the conduit and reinforcing steel. The conduits shall be adequately fixed to prevent excessive movement and damage during the pouring and settling of concrete and shall be protected from mechanical damage.

Where conduits are left "open ended" prior to wiring they shall be protected by caps or plugs to prevent the ingress of building materials etc.

The building construction may require particular treatment in respect of the fixing of conduit and/or fittings in order to obtain permanent security. The drilling and tapping of non-structural steelwork, the supply and fixing of metal straps, supports, clips, clamps and plates and the introduction of additional conduits of larger sizes than actually required for wiring, together with all fixing devices, must be included for wherever such practices are necessary, and particularly when luminaires etc., have to be supported independently of specially suspended ceilings. The Engineer's written approval shall be obtained before any hole is drilled or cut in structural steel or structural concrete.

17.6 Locking, Bushing and Coupling

All conduit ends must be filed square and reamed before erection to ensure freedom from internal burrs and roughness. All inside surface of the conduit system shall be free from projections.

Running couplings shall only be used where absolutely necessary. All running couplings shall be secured by means of lock nuts or lock rings.

Care shall be taken to ensure all locknuts seat firmly into the adjoining surface.
On galvanised steel conduit installations galvanised internal threaded couplings shall be used.

Every conduit connection to equipment, boxes, distribution boards, loop-in boxes, cable trunking etc. shall be made by means of a smooth bore brass bush. The smooth bore bush shall be fitted to secure the conduit to the item connected via a purpose made clear hole only sufficiently large to permit the bush to be rotated, the hole to be closed by the bush and coupling with all bushes on the inside of the item of equipment. Bushes shall be fitted and tightened by means of correctly fitting spanners.

Mutilated bushes must not be fitted, and any bushes damaged whilst being fitted must be removed and replaced.

Conduits connecting by couplings shall be connected by means of a 15mm long threaded section and shall have a gap of approximately 2mm between the adjoining threads. No threads shall be exposed except at running couplings.

All free ends of conduit shall be fitted with brass female bushes.

The complete conduit system shall be so arranged to ensure that any condensation arising in any part of the system shall drain to a suitable drainage point.

Specific anti condensation measures shall be taken where appropriate.

17.7 Continuity and Earthing

The whole of the conduit installations shall be mechanically and electrically sound. The integrity of the conduit continuity shall be tested with an appropriate test instrument, in accordance with the current edition of BS 7671/A1.

Install a separate protective conductor in all conduit systems.

17.8 Painting of Conduit

All exposed threads shall be painted and all conduits which have suffered minor damage shall be made good to prevent oxidation. Lubricants or cutting compound shall be removed from conduit prior to painting. Galvanised conduit which is slightly damaged shall be primed and painted with a metal-based paint to match the colour finish of the conduit.

Conduits which are in the opinion of the Engineer more than slightly damaged shall be rejected and replaced.

17.9 Insulated Conduit Systems

Insulated conduits shall be heavy gauge, high impact non-metallic conduits and fittings for Electrical Installations. All conduit boxes, couplings, draw-in boxes, etc., shall be of the same manufacture and quality as the conduit. The conduit shall be suitable for use in ambient temperatures up to 55°C. The conduit shall be non-hygroscopic and self-extinguishing.

No elbows, tees or inspection bends will be permitted.

During the course of the installation of the conduit system, procedures for working and dressing the installation as recommended by the manufactures shall be employed.

All bends and sets shall be in accordance with Part 5 of the current edition of BS 7671/A1 formed with the aid of a helical spring fitted internally, with, if necessary, the conduit warmed sufficiently for it to move without deformation of the bore, and without avoidable wall thinning on the outside of the bend.

Insulated conduit shall be protected during storage and during installation by means of wooden plugs, plastic plugs or plastic caps to prevent the entrance of plaster or foreign matter. Protection shall also be afforded against mechanical damage.

Surface conduits shall be supported by galvanized spacer bar saddles painted to match the conduit, which shall be fixed at a maximum of one metre intervals except for bends where saddles shall be positioned 200 mm on either side of the bend. Conduits shall be free to slide within the saddles.

All saddles, tubes and boxes must be in perfect alignment to prevent warping when the installation is complete.

Expansion couplings shall be installed where any length of conduit, inclusive of draw-in boxes etc. exceeds five metres in length.

The minimum size of conduit shall be 20mm diameter. Conduits conforming to the above requirement shall be selected and so arranged with draw in boxes to allow easy drawing of the cables.

Where luminaires or other items of equipment are required to be supported from an insulated conduit system the maximum weight supported shall be 3 kg. and the box or boxes shall be fitted with metal support lugs within each box.

Enclosed tungsten luminaires shall not be fixed directly beneath a conduit run but shall be mounted on a heat resistant box spurred off the main run.

The back plate of accessories shall be securely fixed, and two saddles shall be fixed immediately adjacent on either side of the accessory.

Insulated conduit systems shall never be installed where the ambient local temperature is expected to exceed + 55°C or fall below -5°C. Where insulated conduit tube sections and fittings or accessories are required to be jointed the manufacturer's proprietary jointing cement shall be applied to both surfaces, and the tube fittings rotated to ensure complete coverage. The manufacturer's recommendations must be adhered to with regard to jointing procedures. Where expansion joints occur, these shall be made with the manufacturer's purpose made 'tacky' watertight expansion jointing cement to ensure adequate movement of the system during temperature changes.

All insulated conduit systems shall be fixed with an approved spacer bar saddles with fixing centres no greater than 300mm. Fixing of these saddles shall be similar to that specified for galvanised conduits.

Throughout the entire system of an insulated conduit scheme green and yellow coloured and insulated protective conductors shall be installed in accordance with the current edition of BS 7671/A1. The minimum size for the protective conductors shall be 1.5 mm².

Conduits in floors shall be routed and installed so as to avoid any fixings that may be required for floor standing equipment.

The precise location of any conduits installed in floor screeds shall be accurately dimensioned on the record drawings.

17.10 Flexible Conduit

All flexible conduit shall comprise PVC sheathed galvanised flexible metallic tubing complying with BS EN 50086-23. It shall be used for the final connection from a rigid conduit installation to the terminal boxes of all equipment provided with a means of positional adjustment and/or where vibration may reasonably be expected to occur.

Flexible conduit shall be terminated using approved glands, couplings and bushes with serrated washer fitted to all bushes on the inside of the equipment. External terminations shall also have a neoprene or rubber washer between coupling and equipment.

In all instances a separate PVC insulated green and yellow coloured protective conductor complying with the current edition of BS 7671/A1 shall be installed and terminated at each end into purpose made earthing terminals.

Under no circumstances will flexible conduit be accepted in lieu of sets and bends in rigid conduit installations.

In normal circumstances flexible conduit shall have a minimum length of 300mm and a maximum unstretched length of 700mm. It shall permit a full range of withdrawal, adjustment or movement of the equipment.

18.0 Wiring in Conduit and Trunking

18.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671/A1	Requirement for electrical installations.
BS EN 50525	Thermosetting insulated and thermoplastic sheathed cables for voltages up to and including 450-750V for electric power, lighting and internal wiring and having low emission of smoke and corrosive gases when affected by fire.
BS EN 50525-3-31	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U ₀ /U). Cables with special fire performance. Single core non-sheathed cables with halogen-free thermoplastic insulation, and low emission of smoke
BS EN 50525-3-41	Electric cables. Low voltage energy cables of rated voltages up to and including 450/750 V (U ₀ /U). Cables with special fire performance. Single core non-sheathed cables with halogen-free crosslinked insulation, and low emission of smoke

18.2 General

All power cables installed in conduit and trunking shall be selected in accordance with BS 7671 and be LSZH to relevant parts of BS EN 50525, 450/750V grade, with conductor stranding of either class 2 (stranded, minimum of 7 strands, H07Z-R or H07Z1-R) or class 5 (flexible, H07Z-K or H07Z1-K).

The quantity and size of cables contained in any one conduit shall comply with Part 5 of the current edition of BS 7671/A1. Prior to commencement of wiring the conduit system shall be swabbed to render it free from moisture and foreign matter.

No conductor with cross-sectional area of less than 1.5 mm² shall be used for lighting circuits and 2.5 mm² for circuits supplying socket outlets. The conduit installation shall be completed before wiring is undertaken.

No wiring shall be carried out before plastering or screeding is completed and has dried out, and in all cases, permission must be obtained from the Engineer in writing before wiring is commenced.

Final circuits shall be run in conduits separate from main or sub-main cables. All cables in a conduit shall be drawn in simultaneously.

All cables shall be installed in the loop in system. No joints shall be made at points other than accessories without the written permission of the Engineer.

Cables shall be drawn into the conduit directly from reels, neatly and without crossovers. Care shall be taken to protect the cables from abrasion or other damage whilst being installed.

All cables shall be drawn in without the use of excessive force without the use of lubricants and the wiring shall be easily withdrawable.

Co-ordination with other services in respect of free access to draw-in boxes shall be ensured.

Cables shall not pass through luminaires unless the luminaires are part of a specifically designed trunking system with a wiring way protecting the cables from mechanical damage and/or heat.

The wiring of the installation must be done in strict accordance with the drawings, cable sizes and circuit details given in the Specification and Schedules or Drawings issued for the particular project.

On all power circuits (AC and DC), care must be taken to ensure that both the respective phase and neutral are contained in the same conduit and that no single current carrying conductor is present within a steel conduit or trunking, or passes through a steel aperture.

The minimum length of spare cable generally to be left at each accessory shall be 150 mm per conductor, to enable terminations to be re-made, excessive cable length shall not be left at accessories.

Lids of all conduit and adaptable boxes and trunking shall not be fitted until the Engineer has had the opportunity to inspect the wiring and given permission for them to be fitted. The Engineer shall be given at least 5 working days' notice of the intention to wire the installation and to fix lids.

All cables at distribution boards shall have sufficient length enabling termination at any way within the board.

18.3 Cable Terminations

Cables shall be terminated in accordance with Part 5 of the current edition of BS 7671/A1 with particular regard being given to electrical connections.

Cables shall be terminated by one of the following methods: -

- a) The cable conductors shall be sweated into lugs of the appropriate size for the cable and equipment terminal.
- b) The cable conductors shall be secured by compression type lugs of the correct size for the cable and equipment terminal.
- c) The cable conductors shall be secured in pinch screw terminals. Conductors with class 5 (flexible) stranding shall be prepared with appropriate crimp or ferrules prior to termination in pinch screw terminals in accordance with BS 7671.
- d) The cables shall be secured by means of clamps.

Where cables are required to terminate into connectors at lighting points, such connectors shall have two compression screws and in luminaires in which temperatures exceed 50°C, shall be insulated with porcelain.

The cross-sectional area of cable conductors shall not be reduced at terminations, and connections shall secure all the strands of class 2 (stranded) and class 5 (flexible) cables. Care shall be taken to ensure that cables are not damaged during preparation of the termination.

Class 2 stranded conductors of the same wire terminating at pinch screw terminals shall be twisted together. Where a single class 1 (solid) conductor terminates at a pinch screw terminal, it shall be doubled back to ensure adequate purchase for pinching screws.

Cables connected to lamp holders or other components at which heat is produced shall be insulated with heat resisting material capable of withstanding, without detriment, the temperature encountered.

19.0 Cable Trays

19.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 10346	Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions.
BS EN 61537	Cable management. Cable tray systems and cable ladder systems.

19.2 General

Cable trays shall be installed generally as indicated on the tender drawings and shall be of Admiralty pattern heavy duty return flange type, Hot-Dip Pre-Galvanised.

The tray layouts indicated on the drawings show the main routes as the minimum requirement. Any additional trays deemed necessary to complete the works shall be shown on the installation drawings prepared and submitted to the engineer for approval. The approval of any such additional trays will be at the discretion of the Engineer. Any additional cable tray systems shown shall be at no extra cost to the contract as they will be deemed to be in the place of clipped cables which should have been allowed for in order to provide for a complete cabling system.

The trays shall be coupled by means of rigid edge bars and fishplates, mushroom head screws, nuts and shakeproof washers through the flanges, onto the tray where cables are to be laid. Screws, nuts and washers shall be cadmium plated.

Effective continuity between sections of trays shall be ensured by separate copper bonding strips bolted across each coupling point. The contact surfaces shall be thoroughly cleaned prior to bonding. All cable trays shall be connected by protective bonding conductors at relevant points to the protective earthing system.

Full use shall be made of standard purpose manufactured components, i.e. bends, tees, reducers, intersections, and risers to suit the installation. All bends and tees shall be of the gusset type.

Cable tray for horizontal runs suspended from the ceiling shall be installed with the flanges facing upwards, and the tray shall be supported with purpose made mild steel trapeze straps or brackets at sufficient centres to prevent the tray from sagging and shall provide an overall rigid construction.

Where space allows horizontal cable tray routes shall be suspended from the soffit on drop rods and support brackets at a height which shall allow cables to be laid on top of the tray. Cables shall be supported over their entire length and evenly distributed across the width of the tray.

Cable tray fixed to walls or ceiling soffits shall be installed with the flange outwards or downwards respectively and shall be fixed with an approved fixing with spacing washers such that the tray is at least 10mm from the surface of the wall or ceiling.

Supply and install all tray support steelwork and fixings and size the system capacity to support the designed cable load plus 30% spare capacity. The maximum tray deflection between the fixings when fully load shall not be greater than 10mm.

Cables shall be cleated to the tray system with proprietary cable cleats or saddles.

The complete installation shall be free from burrs and sharp edges.

The routing and exact method of installation of cable trays shall be approved by the Engineer before installation. All cables installed in trays shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671:

- Under no circumstances shall cables be fixed to the underside of cable trays.
- Where vertical runs of cable tray are approved by the Engineer, metal ties, cleats or fasteners shall be used to secure cables to the tray.

Cables associated with telephones, data, radio and television systems shall not be run on a common tray with any other services unless specified otherwise.

Cable trays installed in external areas shall be selected for the environment in which they are installed. They shall be installed as indicated on the tender drawings and a minimum corrosion resistance Class 7 to BS EN 61537, post – galvanised, whichever is higher.

20.0 Cable Baskets

20.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 2081 BS 12329	Metallic and other inorganic coatings. Electroplated coatings of zinc with supplementary treatments on iron or steel
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 10346	Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions
BS EN 61537	Cable management. Cable tray systems and cable ladder systems.

20.2 General

Cable baskets / wire trays shall be installed generally as indicated on the tender drawings.

The basket / wire tray layouts indicated on the drawings show the main routes as the minimum requirement. Any additional baskets deemed necessary to complete the works shall be shown on the installation drawings prepared and submitted to the engineer for approval.

The approval of any such additional baskets / wire trays will be at the discretion of the Engineer. Any additional cable basket / wire tray systems shown shall be at no extra cost to the contract as they will be deemed to be in the place of clipped cables which should have been allowed for in order to provide for a complete wiring system.

Ensure that baskets / wire trays comply with BS EN 61537, are made of high strength steel wires, hot dip galvanized to BS EN 10346, and are formed into wire mesh pattern with intersecting wires welded together. Electro-galvanising BS EN 2081 of baskets / wire trays is not allowed.

Ensure that wire baskets/ wire trays are bonded and earthed throughout. Fix copper connectors across all joints of baskets / wire trays to maintain earth continuity. Ensure that the length of each such copper connector is slightly longer than the distance of its attachment points, to allow for movement or expansion of the joint.

Check that all wire ends along the basket / wire tray sides are rounded during manufacturing, to ensure the safety of cables and installers.

All change of direction, intersections or any other method which allows the basket/ wire tray system to alter direction shall be fitted with proprietary purpose made fillets of the same manufacturer as the basket systems to allow cables on the basket/ wire tray to smoothly sweep round bends during direction change.

Use only centre support hangers, trapeze hangers or wall brackets, to support the basket / wire tray system.

Use side action bolt cutters with offset jaws to cut basket / tray wires; do not use saws, nor cutters with centre cut jaws. Treat all cut edges with a cold galvanized paint.
Use serrated flange locknuts and bolts for all splicing assemblies.

All cables installed in basket / wire tray shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671:

- Under no circumstances shall cables be fixed to the underside of basket / wire tray
- Where vertical runs of basket / wire tray are approved by the Engineer, metal ties, cleats or fasteners shall be used to secure cables to the basket / wire tray

21.0 Cable Ladder

21.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671	Requirements for Electrical Installations. IET Wiring Regulations
BS EN 10346	Continuously hot-dip coated steel flat products for cold forming. Technical delivery conditions
BS EN 61537	Cable management. Cable tray systems and cable ladder systems.

21.2 General

Supply and install all ladder support steelwork, brackets and fixings. Size the system and provide suspension brackets and fixings at centres to support the designed cable load plus 30% spare capacity in accordance with the manufacturers' recommendations.

The ladder layouts indicated on the drawings show the main routes as the minimum requirement. Any additional ladder deemed necessary to complete the works shall be shown on the installation drawings prepared and submitted to the engineer for approval. The approval of any such additional ladder will be at the discretion of the Engineer. Any additional cable ladder systems shown shall be at no extra cost to the contract as they will be deemed to be in the place of clipped cables which should have been allowed for in order to provide for a complete cabling system.

The ladder shall be coupled by means of rigid edge bars and fishplates, dome head bolts, nuts and shakeproof washers through the flanges, onto the ladder where cables are to be laid. Screws, nuts and washers shall be cadmium plated.

Effective continuity between sections of trays shall be ensured by separate copper braid bonding strips bolted across each coupling point. The contact surfaces shall be thoroughly cleaned prior to bonding.

Full use shall be made of standard purpose manufactured components, i.e. bends, tees, reducers, intersections, and risers to suit the installation. All bends and tees shall be of the gusset type.

Horizontal cable tray routes shall be suspended on drop rods and support brackets at a height which shall allow cables to be laid on top of the ladder. Cables shall be supported over their entire length and evenly distributed across the width of the ladder.

Cable ladder fixed to walls shall be installed with the flange outwards and shall be fixed with an approved fixing with spacing washers such that the ladder is at least 10mm from the surface of the wall.

All cables installed on cable ladder systems shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671. Cables shall be cleated to the ladder system with proprietary metal cable cleats or saddles.

The complete installation shall be free from burrs and sharp edges.

The routing and exact method of installation of cable ladder shall be approved by the Engineer before installation.

Cable ladders installed in external areas shall be selected for the environment in which they are installed. They shall be installed as indicated on the tender drawings and a minimum corrosion resistance Class 7 to BS EN 61537, post-galvanised, whichever is higher.

22.0 Power Supply Cables

22.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 3988	Specification for wrought aluminium for electrical purposes, solid conductors or insulated cables.
BS 6121-1	Mechanical cable glands. Armour glands. Requirements and test methods
BS 6121-5	Mechanical cable glands. Code of practice for selection, installation and inspection of cable glands used in electrical installations
BS 6622	Electric cables. Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV. Requirements and test methods
BS 6724	Electric cables. Thermosetting insulated, armoured cables of rated voltages of 600/1 000 V and 1 900/3 300 V for fixed installations, having low emission of smoke and corrosive gases when affected by fire. Specification
BS 7671/A1	Requirements for Electrical Installations
BS 7769	Electric cables. Calculation of the current rating
BS 7835	Electric cables. Armoured cables with thermosetting insulation for rated voltages from 3.8/6.6 kV to 19/33 kV having low emission of smoke and corrosive gases when affected by fire. Requirements and test methods.
BS EN 10257-1	Zinc or zinc alloy coated non-alloy steel wire for armouring either power cables or telecommunication cables. Land cables.
BS EN 50575	Power, control and communication cables — Cables for general applications in construction works subject to reaction to fire requirements
BS EN 60228	Conductors of insulated cables
BS EN 60287	Electric cables. Calculation of the current rating
IEC 60502	Power cables with extruded insulation and their accessories for rated voltages from 1 kV ($U_m = 1,2$ kV) up to 30 kV ($U_m = 36$ kV)

All cables shall comply with the European Construction Products Regulations.

All cables shall be approved by an independent accredited certification body such as BASEC or equivalent European equivalent.

22.1.1 General

The exact type of cable termination will be dependent upon the application and shall be confirmed by the engineer or specified within the tender documents.

Where there is risk of moisture penetration to the joint then oil-based compound shall be used.

Cable seals shall remain fixed to the cable until the work area is ready to receive the termination and connection of the cables. Take account of all adverse environmental conditions and provide suitable protection.

All cables installed externally and exposed to direct sunlight shall be provided with a UV-stable sheath.

22.1.2 Cable Selection

Where the selection of cables is required, particularly for buried cables at varying depths and varied soil thermal resistivity, the cable current rating shall be calculated in accordance with BS 7769 and BS EN 60287.

22.2 High Voltage Cabling

22.2.1 XLPE/PVC Type

Unless specified otherwise, 11kV cables shall comprise:

- 12kV grade XLPE insulated stranded copper conductors to BS 6622 and IEC 60502
- Single wire armoured
- overall red coloured PVC or LSZH sheathed
- copper screened

The complete construction shall comply with BS 7835 unless otherwise stated and be of an appropriate rated voltage.

An extruded semi-conducting layer of XLPE shall be provided over the conductor for each cable that is to operate at 3.8 / 6.6kV and above.

Terminations shall be made using BS 6121-1 glands with cast integral compression type lug. Glands shall be installed in accordance with BS 6121-5.

22.2.2 General and installation

Joints shall be the resin compound type unless otherwise detailed. Where a screened cable is to be jointed to a belted cable a proprietary joint shall be used and made in accordance with the cable manufacture's and jointing kit manufacturer's recommendations.

The connections shall be compression crimped lug type. The lug and connection shall be capable of withstanding the expected maximum prospective short circuit level without incurring a detrimental effect to the installation.

Only competent operatives with high voltage cable jointing training shall be employed to carry out terminations and connections. Documentation shall be made available to demonstrate that the operatives have received a recognised qualification from a reputable training authority for the cables being worked.

Manufacturer's instructions shall be adhered to when jointing, terminating or connecting high voltage cables.

Cable bends shall be in accordance with the manufacturer's recommendations. All cables shall be supported in accordance with the manufacturer's recommendation and to ensure that they are not exposed to undue mechanical strain on the conductors or terminations.

The terminations cable shall only be worked when the local environmental conditions are favourable to prevent moisture and foreign matter entering the termination. Where there is risk of moisture or foreign matter entering the termination provide suitable protective measures that are in agreement with the engineer.

Cables shall be terminated at the equipment served by a mechanical type cable gland, complete with armouring clamps. Allowance shall be made for all the necessary cable glands, terminations, earth rings, shrouds and cable markers to complete the installation.

The Contractor shall provide for the supply and installation of Traffolyte labels fixed at both ends, of each cable and at appropriate interval, (e.g. Transition through walls, levels, fire barriers etc.) to clearly indicate the size, type and identification number of each cable.

All support systems shall be electrically continuous. Copper earth links shall be installed between all interconnecting lengths and accessories of the cable support system. Each individual support system structure shall have a main equipotential bond to the main earthing bar using 35mm² low smoke and fume zero halogen green/yellow copper cables.

All cable ladder installations for the High Voltage cable installation shall be fitted with slow radius bends, tees and crossovers with a minimum internal radius of 600mm or greater to suit the minimum bending radius of the HV cable in accordance with the manufacturer's recommendations.

22.3 Low Voltage Cabling

22.3.1 XLPE Insulated Power Cables

These cables shall comprise stranded copper conductors, unless specifically detailed otherwise, insulated with thermosetting insulation, an inner LSZH extruded bedding armoured with a single layer of galvanised steel wires and served with a LSZH oversheath marked 600/1000V ELECTRICAL CABLE.

Core identification shall be by pigmentation of the insulation. The cables shall be manufactured in accordance with BS 7835.

22.3.2 General and Installation

Where the armour wires of cables are used to provide protective conductors they shall comply with the requirements of Parts 4 and 5 of the current edition of BS 7671.

Unless permission is given by the Engineer no joints in cables will be allowed. In the event of joints being unavoidable, they shall be made using plastic joint boxes of approved design filled with an approved cold pouring plastic or resin potting compound. The cable box shall incorporate suitable copper tapes and clamps to bond the armouring of the jointed cables. The conductors shall be joined with maintenance-free compression joints, and the conductors shall be wrapped with LSZH tape, prior to application of the potting compound, to give a degree of insulation at least equal to that of the original insulation.

Compression crimp joints shall be made with the correct size tool and pressure for the ferrules used. Cables shall be terminated in the cable manufacturer's approved glands. These shall be of the compression type providing controlled radial compression of the sheath. The gland shall incorporate an armour clamping ring and earthing ring, and where used outdoors, a lead washer shall be used to ensure a watertight joint between the gland and the unit to which it is fitted.

The earthing ring shall be rigidly fixed to the item of equipment using brass nuts, bolts and washers.

A protective conductor with crimped lug shall be inserted between the brass bolt and the earth bar of the system.

All gland terminations shall be protected by a shroud which shall fit tightly over the cable. The shroud must be threaded over the cable before the gland is fitted.

All cables shall have the cores connected to bolted connections in busbars etc., by means of compression type terminations, made off by means of hydraulic compression tools and a suitable die to suit the cable size.

Each terminal shall be fitted with a brass washer between the socket and securing nut or bolt to ensure good electrical contact.

Crimping sockets for use with tunnel type terminals shall be of the pin type manufactured from brass or copper, made off as described above, pin diameter to suit terminal tunnel.

Where cables having aluminium conductors are specified, aluminium/copper bi-metal socket and pin type terminations shall be used.

Cable bends shall be in accordance with the manufacturer's recommendations. All cables shall be supported in accordance with the manufacturer's recommendation and to ensure that they are not exposed to undue mechanical strain on the conductors or terminations. Cables shall be fixed with proprietary metal cleats generally fixed to cable tray or ladder support systems to prevent premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671. PVC tie wraps or plastic cleats shall not be acceptable.

All cable routes shall be agreed with the Engineer. No claim on the ground of lack of knowledge will be entertained.

Cable spacing has been taken into account when cable sizes were calculated. On no account may the cables be arranged other than as shown on the drawings without the written approval of the Engineer.

All cables shall be clearly marked with their reference at each end of the run and at all right-angle bends, Proprietary cable marker tags shall be utilised.

After the cables have been installed and terminated, but prior to putting into service, they shall be subjected to an insulation test of 500 V and the results of these tests (recorded on test sheets) forwarded to the Engineer. The Engineer shall witness the tests and shall be given forty-eight hours' notice to arrange for suitable representation.

22.3.3 Aluminium Solid Sector Cables

Where cables having solid aluminium sectors conductors are specified, they shall comply with BS 3988.

23.0 Cables Laid in the Ground

23.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6920	Suitability of non-metallic materials and products for use in contact with water intended for human consumption.
BS EN 60529	Degrees of protection provided by enclosures
BS 7671	Requirements for electrical installations
NJUG Volume 1	NJUG Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus

23.2 General

Cables laid directly in the ground are to be installed in accordance with BS 7671, in trenches at a minimum depth of 750 mm below ground level on a 75 mm bed of sand.

Trenches are to backfilled and consolidated; a layer of sand not less than 75 mm deep being laid immediately over the cable. The cable shall be protected by earthenware or concrete cable covers of approved manufacture, and to be clearly marked with words "Danger Electricity". These covers are to be laid over the entire length of the cable and immediately above the sand covering. At depth of 300 mm yellow/black PVC marker tape shall be laid with the words "Danger cable buried below".

Where cables feeding separate services of differing voltages are accommodated in the same trench, the cables shall be laid not less than 300mm apart and shall each be covered by covers of different pattern so that the services may be easily identified.

Beneath roadways, car parks, building, etc., cables shall be enclosed in internally glazed earthenware cable conduits and be arranged and colour-coded in accordance with National Joint Utilities Group (NJUG) Volume 1 – NJUG Guidelines on the Positioning and Colour Coding of Underground Utilities' Apparatus.

Beneath roadways cable and ducts shall be laid at a minimum depth of cover of 900 mm below road surface level.

The route of the cable or cables shall be clearly marked by cable markers of approved pattern at each bend or change of direction of the cable path and every 45 m of straight run. In grassed areas the markers shall be set flush in the ground, and of a minimum area of 200 mm x 150 mm.

23.3 Exposure to Moisture

Cables submerged in water or are in constant contact with water, including those cables in ducts or pits below the seasonal water table or otherwise might be subject to seasonal inundation, shall be:

- declared by the manufacturer as suitable for installation in the relevant environmental conditions at the:

- cables that will be submerged in water at a depth greater than 1 m below the surface of water shall be suitable for the AD8 external influence condition according to Appendix 5 of BS 7671, equivalent to IPx8 according to BS EN 60529, for submersion at the relevant depth
 - cables that will be immersed in water at a depth of 1 m or less below the surface of water shall be suitable for the AD7 external influence condition according to Appendix 5 of BS 7671, equivalent to IPx7 according to BS EN 60529
- Comprise of water resistant MDPE sheathing material
 - longitudinally watertight using water-blocking or water swellable tapes and water swellable powders
 - laterally (axially) watertight using water resistant rubber sheathing materials or using water-blocking or water swellable tapes and water swellable powders

Joints of such cables that are submerged or immersed in water shall be:

- Generally, of the potted or gel-filled type
- Declared by the manufacturer as suitable for installation in the relevant environmental conditions:
 - cables that will be submerged in water at a depth greater than 1 m below the surface of water shall be suitable for the AD8 external influence condition according to Appendix 5 of BS 7671, equivalent to IPx8 according to BS EN 60529, for submersion at the relevant depth
 - cables that will be immersed in water at a depth of 1 m or less below the surface of water shall be suitable for the AD7 external influence condition according to Appendix 5 of BS 7671, equivalent to IPx7 according to BS EN 60529

Cables and joints submerged in potable water shall comply with BS 6920 and be approved for use under the Water Supply (Water Fittings) Regulations.

24.0 Mineral Insulated Copper Clad (MICC) Cables

24.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	STEEL CONDUIT AND FITTINGS WITH METRIC THREADS OF ISO FORM FOR ELECTRICAL INSTALLATIONS PART 2: FITTINGS AND COMPONENTS
BS 4568-2	Steel Conduit and Fittings with Metric Threads of ISO Form for Electrical Installations Part 2: Fittings and Components
BS 7671	Requirements for electrical installations
BS EN 60702-1	Mineral insulated cables and their terminations with rated voltages not exceeding 750 V. Cables
BS EN 60702-2	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Terminations
BS EN 60702-3	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Guidance for use

24.2 General

Where mineral insulated copper sheathed cables (MICC) are specified they shall be installed only by tradesmen skilled and trained in the use of such cables. The whole of the installation shall be carried out in accordance with the manufacturer's recommendations and by use of the manufacturer's recommended tools.

24.3 Cables

All MICC cables shall be in accordance with BS EN 60702-1 being of 600-Volt grade unless other grades are requested. All cables and accessories shall be manufactured with LSZH sheaths as specified in subsequent sections of the Specification. Where LSZH or LSOH sheathed MICC cables are used all other items such as clips and shrouds shall be of or sleeved in the same material and colour.

The minimum conductor cross sectional area for lighting circuits shall be 1.0 mm² and for all other power circuits 1.5 mm².

Unless detailed otherwise the Classification of circuits shall be by colour of the LSZH oversheath and the following code shall be adhered to: -

SHEATH COLOUR	SERVICE
Red over sheath	Fire Alarms (White may be used for aesthetic reasons in high specification areas)
White over sheath	Emergency Lighting
Orange over sheath	General Services

24.4 Clips and Saddles

Single MICC cables may be supported by heavy gauge one-hole fixing 'P' clips, or one, two or three-way heavy gauge saddles for multiple cable runs. Spacer bar saddles shall only be used where indicated in the Specification.

Saddles and clips shall be fixed by brass round headed wood screws, plastic plugs being used for erection on concrete brickwork. Supports shall be placed not more than 300 mm apart and not more than 150 mm from a termination or bend on small cables, greater distance may be permitted on heavy cables and on vertical runs. Larger cables shall be fixed at intervals not greater than recommended by the manufacturer and in all cases sufficiently close to securely fix the cable with no flexing.

Where two or more cables are installed together on the surface they shall be installed on cable tray unless the use of multiple saddles is specified in subsequent Section of the Specification.

Sleeved clips and corrosion resistant screws shall be used in corrosive situations.

Cables shall be straightened and dressed neatly into place during fixing, without damage to the cable finish.

24.5 Method of Installation

MICC cables shall be installed in accordance with BS EN 60702-2, BS EN 60702-3 and BS 7671.

Ensure that workmen are fully conversant with and highly skilled in the installation of MICC cables, and that they have received an approved course of instruction in the installation and termination of all types of MICC cables. Submit details of training given to each individual, when requested by the Engineer.

The manufacturer's recommended tools shall be used throughout the work.

All bends shall be neat and uniform and not less than six times the diameter of the cable. Bending levers with padded surfaces shall be used for making all bends and offsets in cable larger than 10mm in diameter. Offsets where cables enter fittings shall be bold and definite with 50mm of straight cable between gland and first bend.

Where cables pass through holes in the building structure, short lengths of insulated conduit shall be threaded over the cables for protection against abrasion.

All holes shall be suitably plugged with flexible material or a weak mortar mix, after the cables have been installed.

Where surface mounted cables pass through floors, they shall be protected to a height of two metres by galvanised steel conduit fitted with coupling, bush and sealing compound through which the cable shall pass in order that moisture etc. is excluded.

All parallel cable runs shall be grouped in a neat and orderly manner without cross-overs, so that all cables may be readily identified and any cable easily removed at a later date.

Where MICC cables are installed in walls they shall be run square and vertical; cables run at an angle or in a zigzag fashion will not be permitted.

All MICC cables laid underground shall be LSZH/ LSOH sheathed and laid at a depth not less than 750 mm in accordance with the requirements for cables laid in ground as detailed elsewhere in this Specification. Where subsidence is likely to occur allowance shall be made for 'snaking' the cables.

Care shall be taken not to scratch the copper sheathing or break the LSZH/ LSOH sheath. Any cables damaged in this way shall be replaced at no additional cost to the contract.

Where MICC cables are fixed in contact with cable tray, stonework, etc., likely to give rise to corrosion, or drawn through conduit, the cables must be provided with LSZH/ LSOH sheathing.

Joints in MICC cable shall only be made at terminations to equipment and accessories. No joints shall be made in through boxes without the written approval of the Engineer.

Where a cable is required in excess of the manufacturer's maximum manufactured length the cable shall be extended by means of a factory-made cable joint. Cables shall not otherwise be jointed. All adjacent cables shall be run in the same horizontal or vertical straight lines, diagonal runs are not permitted.

Where single MICC /LSZH/LSOH cables enter metal clad switches etc. the holes drilled in the end plates to accommodate the cable glands shall be inter-connected by means of a 5 mm wide slot to prevent overheating, due to circulating and eddy currents, at one end, and an insulated plate fitted at the other with one cable only bonded to the equipment. The slot through the gland plate shall be sealed with a proprietary sealing compound. Cables used for this purpose shall be fixed using distance saddles.

MICC cables shall be looped one complete turn where connections are made to motors, and other equipment where vibration or expansion is likely to occur. The manufacturer's recommendations shall be followed for the best method of expansion joint relating to the size of cable to be used.

Surge suppressors shall be fitted to termination of MICC cables at contactors and three phase star connected motors and at connections to discharge luminaires.

24.6 Cable Terminations

The ends of all cable shall be terminated with sealing pots made off without delay in accordance with the manufacturer's instructions. All pots shall be of the screw on type. All terminations shall comply with BS EN 60702-2.

Unless detailed otherwise, all glands shall be of the brass Universal ring compression type and all seals shall be of the cold (105°C) type filled with the manufacturer's recommended plastic compound. Cable seals shall not project into the interior of any boxes, distribution boards etc. A coupling and male brass bush shall be used at all non-spouted entries.

Where LSZH sheathed MICC cables are employed each gland shall be fitted with a LSZH/ LSOH shroud, at all terminations, which must be threaded over the cable before the gland is fitted.

Where MICC cables are terminated into plastic accessories or into special MICC glandless boxes or in any situation where the cables are terminated without a gland, the gland pot shall be complete with an integral earth tail installed into a pot by the manufacturer. The earth tail shall be connected to the earthing terminal inside the accessory or apparatus.

Unless detailed otherwise, all conductors at terminations shall be insulated with continuous 'Neoprene' or where necessary silicone rubber heat resistant sleeving, they shall then be identified by coloured PVC insulated tape or by placing a 10 mm length of coloured LSZH/LSOH sleeving over the conductor insulation.

All tails shall be of sufficient length to remake broken connections.

The system shall be wired on the loop in principle, but where connections would assist to produce an economical installation, permission shall be obtained from the Engineer. Any such connections in conduit boxes shall be made using porcelain pinching screws. Joints in straight runs of MICC will not be permitted.

Galvanised accessories such as conduit boxes etc. shall be used.

All boxes shall be complete with an earth terminal.

In all cases where single conductors of mineral insulated cables of cross-sectional area 4.0 mm^2 and below are secured in a terminal with a pinching screw the ends shall be doubled back before insertion. For cables of cross-sectional area 6.0 mm^2 and above the ends shall be terminated in a cone grip cable socket of the lug or tag type specially manufactured for the purpose and sizes of the conductor concerned.

All joints shall be made in circular conduit boxes complying with BS 4568-2 or in rectangular adaptable boxes which if of sheet steel shall not be less than 16 SWG (1.6 mm). Junction boxes may only be used (with the Engineer's approval) for surface installations.

Where cast boxes and the cases of metal clad gear are not provided with screwed spout entries, they shall be drilled with the appropriate clearance hole to accept a bush and coupling with serrated washer.

Circular conduit boxes complying with BS 4568-2 into which the cable terminations shall be screwed, shall be installed at lighting points except where the luminaires have conduit entries.

All connections within the boxes shall be made by means of porcelain insulated brass connectors with pinching screws.

24.7 Testing MICC Cables

The cables, which shall be delivered to site with the manufacturer's seals and identification labels intact, shall be tested upon receipt. During the installation, each individual cable or complete run shall be tested at least twenty-four hours after sealing with a 500 V insulation tester. A report of these tests shall be handed to the Engineer.

A reading of at least $100 \text{ M}\Omega$ must be obtained between the conductors or between any conductor and the cable sheath, all conductors being dis-connected from any apparatus

All seals shall be tested immediately after completion and re-tested after the whole of the cable installation is complete in each particular section of the works. Any cable which does not exhibit the prescribed insulation resistance will be rejected by the Engineer and must be replaced at no extra cost to the Contract.

25.0 Busbar Trunking Systems

25.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
IEC 61439-1	Low-voltage switchgear and controlgear assemblies - Part 1: General rules
IEC 61439-6.	Low-voltage switchgear and controlgear assemblies – Part 6: Busbar trunking systems (busways)
EN 13601	Copper and copper alloys. Copper rod, bar and wire for general electrical purposes.

All busbar trunking systems shall be approved by an independent accredited certification body such as BASEC or equivalent European equivalent.

25.2 General

All bus bars shall be 3-phase and neutral complete with neutral conductor sized to 100% of phase conductor.

The casing of the busbar may be used as the earth conductor.

The components of the complete bus bar installation shall be ASTA (Intertek) tested and certified. Operating temperatures shall be in accordance with EN 61439-1 and EN 61439-6.

Bus bars shall be of a low impedance sandwich construction. Individual bars shall be insulated.

The bus bar shall be supplied as factory assembled units, rigid in construction and symmetrical in appearance. The construction of trunking sections shall prevent phase reversal at adjacent sections. The joints between trunking lengths shall be formed by removable stack joint and insulator plates shall be provided within the joint to isolate each phase, neutral and earth.

Electrical joints shall be made to maintain the original contact pressure as secure joints and long-term reliability are of the utmost importance. Inspection covers shall be provided to permit periodic inspection of the joints without de-energisation of the bus bar.

The bus bar enclosure shall be made of extruded aluminium sections while all other fixtures and fittings shall be plated for corrosive resistance.

The bus bar systems in each instance shall be rated to withstand the same level of short circuit current and short time rating as the corresponding switchboard. Busbar and end feed units shall be fully type tested and certified to EN 61439.

The busbar systems shall be rated to withstand the RMS fault current, for both three-phase and single-phase short circuits at 400V as indicated within the schedules. The busbars shall be selected with a minimum 3-

phase peak withstand equal to or greater than 2.2 times the rated short time RMS fault withstand for 1 second.

Where copper conductors are specified in the schedules, phase, neutral and integral earth conductors shall be high conductivity copper (99.99%) to EN 13601.

Busbar trunking systems installed shall have low volt-drop performance.

Ingress protection of primary busbar trunking systems installed internally shall be IP55 as standard.

Ingress protection of secondary busbar trunking systems installed internally shall be IP2X as standard.
Ingress protection of busbar trunking systems installed externally shall be IP67 as standard.

Bar shall be capable of operating at full load current at the stated ambient temperature without derating.
Bus bar shall be installed as to facilitate thermal imaging survey.

25.3 Installation

The contractor shall provide site surveys to suit the busbar installation into all electrical equipment including the determination of all site dimensions required for manufacture of the bus bar and associated panel flange, bends, fire barriers, expansion joints, bends, and busbar tap-offs.

The contractor shall liaise with the bus bar manufacturer as necessary to provide the bus bar connection.

The Contractor shall obtain from the bus bar manufacturer all pre-production drawings for approval by the engineer and contractor prior to commencement of manufacture.

The bus bar manufacturer shall be confirmed by the client upon award of this tender package
The contractor shall include for:

- the Site Acceptance testing of the busbar trunking
- the load testing of the busbar trunking
- attendance by the busbar manufacturer during IST testing.

The busbar trunking system shall be installed so that

- the joints along the run are accessible and can be replaced without disrupting other services.
- access to bus bar tap off protection devices remain unimpeded
- opening of busbar tap-off doors remain unimpeded.
- be installed so that cable terminations and cable bending radii are unimpeded
- joints and electrical connections are not subjected to undue mechanical stresses, including the effects of thermal expansion and misalignment.

Busbar supports must be provided so that each busbar piece has a minimum of 2 (two) supports holding it in position. Busbar supports shall not be installed at busbar joint packs and shall be installed to provide access so that busbar joint packs can be removed.

Busbar joint packs must not bear any weight from the adjoining busbar pieces. The removal of a busbar Joint pack must not result in the adjoining busbar pieces from falling away because they are not adequately supported.

The Contractor shall install busbars in accordance with manufacturer's recommendations and instructions and all relevant standards. The Contractor shall check total length of bus bar system required on site and produce fully detailed and dimensioned drawings for comment prior to manufacture commencing.

The Contractor shall anchor bus bars rigidly in a minimum of one position and provide means of absorbing maximum expansion and contraction likely to occur in bus bars under normal operating conditions and provide expansion joints in each length of run as required. The busbars shall be supported so as to ensure that the installation of tap-off units does not distort the busbar. Supports for the tap-off units shall be installed as required.

The Contractor shall affix identification and warning labels throughout the length of the busbar system, indicating bus bar reference, ratings and designation.

The Contractor shall provide barriers of fire-resisting materials within the bus bar system where horizontal runs pass through fire break walls/floors, to prevent the spread of fire, in accordance with the fire rating and integrity of the fire compartment.

The Contractor shall provide access equipment such as fixed scaffolding as necessary to install the bus bar trunking.

All anchors and supports of the busbar trunking system

- shall not be loaded above the load capacities recommended by the manufacturers of the anchors and supports.
- shall be installed in accordance with the recommendations of the manufacturers of the anchors and supports.
- It is the responsibility of the contractor to ensure full integration with the building and load bearing structures to support the whole installation.

25.4 Proprietary Fittings

The Contractor shall provide proprietary fittings throughout the busbar system including flanges, joints, bends, elbows and sets to facilitate a complete busbar installation.

The Contractor shall liaise with and provide full details of bus bar flanges to the LV switchgear manufacture to ensure the phase, neutral and earth connections at the LV switchgear aligns with the bus bar orientation.

The Contractor shall also ensure the correct phase orientation is presented at each LV circuit breaker and or LV termination point at all electrical equipment including LV switchgear, transformers, and UPS modules.

Where required the Contractor shall include phase transitions within the busbar system to ensure correct phase orientation.

All busbar trunking system components shall be

- individually labelled with a unique reference that matches the references within testing documentation and record information.
- marked to indicate the arrangement and position of the phase and neutral conductors

The ends of a busbar run shall be fitted with factory fitted End Caps that can be easily removed to allow the extension of the system.

25.5 Tap-offs

All busbar tap-offs shall be compatible with, and shall be made by the same manufacturer of, the busbar trunking system to which the tap-off connects.

Doors shall be interlocked with the isolating circuit breaker, inhibiting opening while the circuit breaker is closed.

Operatives terminating cables into the supply side of the circuit breaker whilst the tap of is fully engaged into a live busbar shall not be exposed to live conductors. The cable connection shall incorporate a form of separation comprising of solid barriers protecting against direct contact. All exposed live conductors on the live side of the Circuit breaker shall be fully segregated and shrouded.

The Tap off unit should allow for the termination of cables to the output of its circuit breaker whilst the Tap off unit is attached and connected to live busbar without such works being defined as “live working”.

The Tap off unit should allow for the replacement of a Tap off unit meter while the Tap off unit is attached and connected to the live busbar, without such works as being defined as “live working”.

25.6 Underfloor Small Power distribution

Where an underfloor small power distribution network is proposed to provide a flexible power solution across a floor to serve socket outlets within floor boxes:

the underfloor distribution will be via underfloor (cavity floor) busbar distribution.

the system shall consist of continuous lengths of bus bar track fed via a feeder unit. The busbar is to comply with the requirements of BS7671

include high integrity earthing (dual earth conductors) with Clean and Functional earth track system protected by a 32A RCBO. The busbar metal chassis can be used as the protective earth.

Provided with proprietary tap-offs for connection from the underfloor busbar system to power outlets and floor boxes.

Floor boxes shall be prewired with a tap-off where connected to an underfloor busbar system.

25.7 Technical submissions

As a minimum provide the following information on the primary busbars for approval.

- Busbar physical dimensions
- Busbar fault rating
- Busbar conductor resistances, reactance and impedances.
- IP rating
- Materials used including conductor materials
- Current carrying capacity for ambient temperatures up to 50 degrees Celsius. Current carrying capacity must including derating factors for high ambient temperatures.
- Current carrying capacity must be provided for all busbar installation orientations including edge wise, flat and vertical orientation
- Recommendations and guidelines on installation practice

As a minimum provide the following information on the busbar tap offs for approval.

- Physical dimensions
- Fault rating and circuit breaker withstand capacity
- IP rating
- Materials used including conductor materials
- Internal construction indicating barriers to prevent direct contact for cable terminations

- Current carrying capacity for ambient temperatures up to 50 degrees Celsius. Current carrying capacity must including derating factors for high ambient temperatures.
- Circuit breaker type, make and model
- Circuit breaker protection device, tripping characteristic curves and discrimination tables
- BMS terminals
- Meter details including communications protocol
- Gland plate locations

25.8 Busbar Testing

All joint & terminations bolts shall be tightened with a calibrated torque wrench to settings as recommended by the busbar manufacturer.

Bolts used for joint connections shall provide visual indication that proper torque has been placed on the bolt.

Torquing shall be witnessed by the client's representative, along with ductor and volt drop tests.

26.0 Lighting Installation

26.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 62384	D.C. or A.C. supplied electronic control gear for LED modules. Performance requirements
2009/125/EC	EcoDesign requirements for energy-related products Directive (ErP)
2011/65/EU	Restriction of the use of certain Hazardous Substances in electrical and electronic equipment Directive (RoHS)
2014/53/EU	Radio Equipment Directive
BS 7671	Requirements for Electrical Installation. IET Wiring Regulations.
BS EN 13032-series	Light and lighting measurement and presentation of photometric data of lamps and luminaires.
BS EN 15193-1	Energy performance of buildings. Energy requirements for lighting
BS EN 60061-2 BS EN 60061-3 , BS EN 60061-1 , BS EN 60061-4	Lamp caps and holders together with gauges for the control of interchangeability and safety. Lampholders
BS EN 60064	Performance requirements for tungsten filament lamps for domestic and similar general lighting purposes
BS EN 60081	Performance specification for double capped fluorescent lamps
BS EN 60155, IEC 60155	Glow starters for fluorescent lamps.
BS EN 60570	Electrical supply track systems for luminaires
BS EN 60598	Luminaires.
BS EN 60598-1	Luminaires. Specification for general requirements and tests
BS EN 60669-1	Switches for household and similar fixed electrical installations
BS EN 60921	Specification for ballasts for tubular fluorescent lamps. Performance requirements
BS EN 60923	Auxiliaries for lamps. Ballasts for discharge lamps (Excluding tubular fluorescent lamps). Performance requirements.
BS EN 60927	Specification for performance requirements for starting devices
BS EN 60929	Specification for performance requirements for DC supplied electronic ballast for tubular fluorescent lamps
BS EN 61048	Auxiliaries for lamps. Capacitors for use in tubular fluorescent and other discharge lamp circuits. General and safety requirements.
BS EN 61049	Performance requirements for capacitors for use in tubular fluorescent and other discharge lamp circuits

STANDARD	TITLE
BS EN 61184	Specification for bayonet lamp holders
BS EN 61347-1	Lamp controlgear. General and safety requirements.
BS EN 61547	Equipment for general lighting purposes. EMC immunity requirements.
BS EN 62031	LED modules for general lighting. Safety specifications
BS EN 62386	Digital addressable lighting interface.
BS EN 62717	LED modules for general lighting. Performance requirements
IEC 55015	Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment
IEC 62386-207	Digital addressable lighting interface. Particular requirements for control gear. LED modules

26.2 General

The lighting installation shall be as shown on the drawings and as detailed in the Particular Specification. The whole of the lighting installation shall be in accordance with BS 7671.

All lighting circuits shall be run in accordance with other sections of this specification. Circuit conductors of a cross sectional area less than 1.5mm² shall not be used.

All luminaires shall be of the manufacture, size and type specified in particular specification and shall comply in all respects to BS EN 60598, relevant parts of BS EN 13032, and relevant parts of BS EN 60598.

The following technical requirements associated to the lighting installations shall be adhered to:

- Luminaire galleries (bodies) shall be fabricated from a minimum of 0.7 mm thick sheet steel with stove enamelled, white epoxy finish.
- Where applicable all corners/flanges on both the body shall be of the welded seamless type or shall be manufactured in one piece to eliminate any seams/joints.
- Luminaires shall incorporate high frequency high power factor electronic control starter gear to suit the lamp types.
- Luminaires shall incorporate removable gear, or as appropriate, driver, trays.
- Anti-Vibration mounts shall be provided for the ballasts, capacitors, and, if necessary, drivers, etc.
- The control gear shall be wired in such a way that should one lamp fail other lamps shall continue to operate.
- The luminaires shall be so constructed that the reflector and wedge type cross-blade controllers' assembly is positively held in position by spring clips. The reflector and the controller shall be removable for maintenance purposes without the need to open "juggle" the assembly. The glare controller shall be earthed to the main body of the assembly by means of a wire strap (the use of a spring clip to affect an earth will not be acceptable).
- Luminaires designated for emergency lighting, facilities shall be provided such that under normal supply failure, one lamp shall continue to operate from a local self-contained 3-hour duration emergency battery.
- Provision shall also be made within the emergency designated luminaires for an LED indicator to be located in the luminaire such that it is visible from below.
- The manufacture of the luminaire shall not start until approval has been given in writing and the works programmed such that two weeks shall be allowed for the Clients approval of the luminaire sample. All comments shall be fully incorporated into the manufacture of the luminaires without causing any delay to the manufacture of the luminaries.

26.3 Luminaires

Supply and install all luminaires including lamps, lamp holders, controlgear, drivers, capacitors, glassware, diffusers or other attachments, heat resistant internal cables, fuses and terminals and all necessary suspension gear.

Luminaires shall not be modified in any way on site without the prior permission and approval of the engineer in writing.

All luminaires shall be assembled and installed in accordance with the respective manufacturer's instructing/recommendations, in the positions and mounting heights specified.

Luminaires shall not be installed under dirty and hazardous site conditions, and any damage or deterioration to luminaires installed under these conditions shall be made good prior to handover.

The luminaires shall be cleaned free of dust, dirt and other deleterious matter after completion of the installation. Where dirt, dust, corrosion, or other conditions cause imperfection in the luminaires, they shall be replaced.

Luminaires, diffusers, attachments of glassware etc., shall be properly stored prior to final erection, in such a manner as to avoid damage of any kind.

All glassware, diffusers, reflectors, etc., shall be left in a clean condition. Allowance shall be made for all plastic surfaces which reflect or transmit light or are visible to view to be treated with an anti-static solution to prevent static electricity.

Luminaire fixings shall generally be suitable for direct connection to conduit boxes or as otherwise specified. The minimum conductor cross-sectional area for flexible cord to the employed shall be 0.75 mm².

Pendant tungsten luminaires shall be fitted with heat resistant flexible multicore cable complying with the relevant part of BS EN 50525, capable of continuous operation with a conductor temperature of 150°C. The cable shall be of the circular multicore type, finished white.

Ceiling mounted tungsten luminaires, spotlights and other luminaires which fall into the category of 'hot' luminaires shall be wired internally with cable suitable for continuous operation of 185°C.

Where cable tails are provided, they shall be of the heat resistant type cable of operation at 185°C and of sufficient length to provide a satisfactory connection to the fixed wiring system.

Exterior luminaires fixed to the walls of buildings etc. shall be wired such that sub-circuit wiring terminates within the luminaire. All sub-circuit cables so installed shall be provided with heat resistance sleeves from the connection point within the luminaire for a distance of 300 mm.

All fluorescent and other discharge luminaires shall be provided with an integral fused connector block fitted by the luminaire manufacturer. The rating of the fuse shall be in accordance with the manufacturer's instruction to protect the internal wiring of the luminaire and to provide discrimination between final circuit protection and luminaire circuit protection.

All recessed and semi recessed luminaires in ceilings shall be connected by three core 0.75mm² high temperature flexible cord from the terminals of the luminaires to a plug-in ceiling rose fixed and connected to an accessible outlet box in the wiring system, within the suspended ceiling immediately above the luminaire. The ceiling rose shall be accessible via the opening provided in the ceiling.

In discharge and other fluorescent luminaires, fuses shall be readily accessible.

All fluorescent and discharge luminaires shall be fitted with suitably rated capacitors that comply with BS EN 61048, BS EN 61049, and ensure that power factor at the luminaire power supply terminals is within the range 0.85 - 0.95 lagging. Where discharge luminaires are fitted with starter switches then capacitors for radio interference suppression shall be fitted ensuring the radio interference from the luminaires is within the limits of EN 55015 & EN 10598-2. The starter switches shall be readily accessible.

All LED Luminaires shall be supplied in batches in order to provide consistency in colour and lumen output throughout the installation.

All LED Luminaires and associated drivers shall be provided with power factor correction so that the power factor at the luminaire power supply terminals is within the range 0.85 - 0.95 lagging.

26.4 Luminaire Installation

Ensure that the methods of suspension for luminaires are electrically and mechanically sound and by means of purpose manufactured metal supports.

Luminaires suspended by means of conduit drops shall be fitted to ball joints allowing a swing of at least 20° all round. Reliable earthing between the fixed and moving parts shall be provided by means of a flexible braided copper tape. The ball joints shall have a stop to prevent rotation by more than 360°. Any deviation from this form of suspension must be agreed with the engineer.

Where conduit suspension is used final circuit wiring shall be contained within the conduit and terminated directly within the luminaire.

Fluorescent luminaires shall be provided with a minimum of two fixings, except in the case of recessed modular luminaires or surface mounting luminaires exceeding 300mm in width, where four number fixings, (one from each corner) shall be provided by means of conduit drops of threaded rods.

Normally visible luminaire support shall be conduit. All fluorescent luminaires shall be solidly mounted with all assembly nuts, bolts and accessories made tight to prevent vibrations and noise. Anti-vibration packing shall be fitted where necessary. Luminaires mounted direct to trunking shall be fixed by means of the manufacturer's recommended fixing assemblies.

Where luminaires are surface fixed and where arranged for end or side entry the conduit shall be installed such that the luminaire body is not utilised as a wireway. The use of 'Tee' boxes to achieve this shall be included. Alternatively, luminaires may be mounted directly onto the conduit run by means of the appropriate quantity (at least 2No) conduit BESA boxes.

Where luminaires are installed in a flush installation the appropriate number of conduit boxes shall be installed. Final circuit connection at discharge luminaires shall be left long enough to terminate at the connections within the luminaire such that cables do not pass over starting/control equipment. Where this cannot be achieved, heat resistant sleeving shall be installed over the cables.

Luminaires shall be fixed using M4 screws to the conduit boxes. Supplementary fixings shall be installed at the end of luminaires over 1200 mm in length.

On single box fixings supplementary fixings shall also be installed to eliminate movement of the luminaires.

Unless stated otherwise all luminaire supports shall be fixed to the building primary structure. Luminaires shall not be supported from suspended ceilings unless detailed otherwise in the specification.

Break joint rings of approved colour shall be provided for all suspended luminaires and fluorescent batten luminaires where the batten is of insufficient width to completely cover the conduit box and its associated clearance hole in the ceiling.

The metalwork of all luminaires shall be effectively bonded to the earthing system.

Care shall be taken to ensure that the internal wiring of luminaires and the cable of any fixed wiring system shall not be in contact with high temperature areas of luminaires.

Fluorescent and LED luminaires controlled by dimmers shall be provided with all necessary additional equipment (e.g. cathode heating transformers etc.) and wiring, such that they will operate in a satisfactory manner and shall be capable of being dimmed to extinction without flicker.

Lighting track shall be of the type, size, finish, number of circuits and manufacture detailed in subsequent sections of the specification and shall comply with the requirements of the relevant parts of BS EN 60598.

The positions of luminaires as shown on the drawings are approximate only and exact positions shall be determined after reference to the engineer's ceiling layout and or setting out details.

LED Luminaires and associated control gear and drivers shall be installed in accordance with the manufacturer's recommendations including requirements for ventilation for heat dissipation and maintenance access. LED luminaires, control gear and drivers shall be installed with sufficient clearance and natural ventilation to prevent them from overheating and to prevent degradation of their life expectancy.

The circuit protection devices protecting all electrical circuits for LED Luminaires and their associated control gear and drivers shall be of a rating and type with sufficient clearing time for the inrush current to clear without creating nuisance tripping.

The maximum allowable LED drivers permitted on each circuit shall be determined by the aggregated magnitude and duration of the inrush current of all the drivers on the circuit. The maximum number of drivers allowed to feed by a single MCB circuit shall be in accordance with the recommendations of the driver manufacturer.

26.5 Lamp holders, Lamps and Ceiling Roses

Lampholders for general use shall comply with the following European Standards:

LAMP TYPE	TYPE OF CAP	EUROPEAN STANDARD
General lighting service (GLS)	B22d	BS EN 61184
General Lighting Service (GLS)	E27 (lamps rated ≤ 2 A) E40 (lamps rated > 2 A)	BS EN IEC 60238
Tubular Fluorescent / LED Tubular Fluorescent Replacement	Bi-Pin c/w earth clamp and 1875	BS EN 60400

Lamp holders for discharge and special purpose lamps shall be as recommended by the lamp manufacturer and detailed in subsequent sections of the specification.

Lamp holders shall be of the heavy T2 or T200 pattern B22 for up to and including 150 watts, E27 shall be used for lamps up to 2 A rating and for mercury and high-pressure sodium discharge lamps. E40 lampholders shall be installed for lamps rated over 2 A. Lampholders shall be complete with skirts.

All E27, E40 and B22 lampholders in totally enclosed luminaires shall be manufactured from brass with insulating parts made from porcelain.

Lamp holders made entirely from porcelain, other than current carrying parts, shall only be fitted in bulkhead luminaires, well glass luminaires, luminaires with porcelain bases and industrial reflector luminaires.

Lamp holders of the bayonet cap type for incandescent lamps up to 150 W rating shall be of the type that has solid plungers and springs which do not carry the current. Where the lamp holder is not an integral part of the luminaire it shall be of the moulded type with cord grip and plain metal bayonet catch and have a skirt. Lamp holders shall be in accordance with BS EN 60061.

Batten lamp holders shall comply with BS EN 61184 and BS EN 60061 and have threaded vitreous porcelain or steatite interiors with solid plugs and springs which do not carry current. Batten lamp holders shall have integral heat resisting conductors wired to terminals to which circuit cables shall be connected.

The lamp holders shall be suitable for direct attachment to conduit boxes and be manufactured from best quality high temperature mouldings with skirt and plain metal bayonet cap.

Every lighting point shall be complete with the number and size of lamps required. Each lamp being rated with the appropriate voltage and wattage.

LED lamps for general lighting service shall be warm white, pearl finish and of European Manufacture to relevant harmonized standards.

26.6 Lighting Switches

Wall and ceiling switches shall comply with BS EN 60669-1. Wall and ceiling switches controlling AC lighting circuits shall be rated 20 A and be of the slow break quick make type unless stated otherwise.

All switches shall be of the grid switch type and shall be supplied complete with box grid switch units and cover plate.

Single pole switches shall be connected only to the phase conductor except as permitted by BS 7671.

All switch assemblies shall comply fully with BS EN 61058 concerning the earthing of plates and operating bars or toggles, where the assembly does not provide a direct reliable electrical contact between the cover plate and box with effective connection of metal operating bars and toggles then an insulated earthing lead shall be provided solidly connected to the metal plate and operating bar or toggle and terminating at a fixed earthing terminal in the box. The provision shall be made in all cases when switches are grid mounted, and also where insulated and sheathed cables are installed.

All switches for wall or ceiling mounting shall be of the approved type complete with switch, grid, cover plate and steel box all of the same manufacture. Switches shall be single or multi-gang, single two way or intermediate, with or without neon indicators, as required. Earthing terminals shall be provided in each switch box.

Finish of plates, switch dollies and screws shall be as specified in the particular specification or as shown on the drawings.

The physical 'layout' arrangement of switches in ganged boxes shall be similar in plan to the lighting points which they control. Switches not so arranged shall be engraved in an approved manner to indicate the circuits controlled, but in any case, all switch plates, six gang and above, shall be suitably engraved to indicate each switch function. The method and style of engravings shall be submitted to the engineer for approval.

All lighting switches shall be ganged as shown on the general lighting layout drawings, being rocker operated and flush or surface mounted, depending upon whether the system or wiring at each particular switch is either fully concealed or a surface installation.

For flush positions on a plastered or equivalently finished wall, the switches shall have overlapping plates.

In any places where the finish is fair faced brickwork the wiring shall be installed on the back of the wall and shall make a back entry into the accessories.

Each switch in these areas shall be neatly recessed and incorporate an overlapping plate.

For surface mounted positions such as plant rooms, electrical switchrooms, etc. employing a surface mounted system or wiring, switches shall be surface mounted having metal front plates of an aluminium stove enamelled finish mounted in matching metal boxes.

In external locations or areas subject to moisture, weatherproof switches and brass fixing screws shall be used.

All door swings shall be certified prior to commencing the installation on site and cord and wall switches shall be positioned adjacent to the casing edge of the door. Wall switches shall be located 150mm to the edge of the mounting box, from the door architrave.

Pull cord switches shall comprise 15 ampere capacity quick make slow break switch action mounted on a high impact resistant non hygroscopic moulded base of the semi-recessed type suitable for mounting in a standard 50mm fixing centre circular BESA conduit box.

Domed covers shall be white insulated. The assembly shall be designed to enable the cores to be renewed without renewed without removing the cover.

Semi-recessed unit shall be complete with a white break joint ring fitted between the conduit box and the switch unit.

The cords of all ceiling switches shall be of sufficient lengths (without joints) to reach a point of 1.5 metres from floor level unless otherwise specified. Cords of excessive length shall be shortened to this height.

Where cord operated 'Pull' ceiling switches are specified to be used at door positions they shall be located on the ceiling in such a manner that the cord will hang free approximately 75mm from any wall face and also be clear of the door movement. Where this cannot be achieved the engineer shall be advised prior to installation.

Fixing of switches shall be by a minimum of 2 number 8 screws fitted into 2 suitably sized plastic plugs recessed into the building structure.

26.7 Indicator Switches

Indicator switch units shall be of the ratings shown on the drawings and shall comprise switch assemblies incorporating a red coloured plastic lens housing a neon indicator lamp which shall glow to show when the switch is in the 'ON' position.

Multiple unit indicator switches shall comply with the above requirements and shall be arranged as a multiple unit in a common cover plate and each section shall be fitted with a light trap to prevent light leakage from one unit to any other.

The cover plate of each indicator switch shall be engraved to show the function of each individual switch.

27.0 Emergency Lighting

27.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 5266-1	Emergency lighting. Code of practice for the emergency lighting of premises
BS 5499-10	Guidance for the selection and use of safety signs and fire safety notices
BS 5499-4	Safety signs. Code of practice for escape route signing
BS 7671	Regulations for Electrical Installation. IET Wiring Regulations
BS 9999	Code of practice for fire safety in the design, management and use of buildings.
BS EN 12193	Light and lighting. Sports lighting.
BS EN 1838	Lighting application – emergency lighting
BS EN 50172, BS 5266-8	Emergency escape lighting systems
BS EN 60598-2-22	Luminaires. Particular requirements - luminaires for emergency lighting
BS EN 61347-2-7	Lamp controlgear. Particular requirements for battery supplied electronic controlgear for emergency lighting (self-contained)
BS EN 62034	Automatic test systems for battery powered emergency escape lighting

27.2 General

The emergency lighting system shall be of the type specified elsewhere in this specification and shall be complete with batteries, chargers, luminaires and wiring all as necessary to provide a complete working installation.

The system shall be so configured to ensure that it operates not only under complete failure of the main electrical system but also under local failure including final circuit failure.

Where conversion kits are specified for luminaires, these shall be factory fitted.

Charging monitors comprising red Light Emitting Diodes (LED's) shall be mounted to be clearly visible when the normal luminaire diffuser is in position. All self-contained luminaires and luminaires incorporating conversion kits shall be fed via a separate live feed from the local lighting circuit. This feed will be switched via a key switch installed in the local lighting switch plate to facilitate the testing of the emergency lighting.

Battery packs for all self-contained emergency luminaires shall be suitable to operate the luminaires for 3 hours and the charger unit shall be suitable to recharge the batteries with 24 hours. The batteries shall high temperature nickel cadmium batteries.

All wiring associated with central battery systems including the interconnection between the central battery distribution panel, local emergency lighting distribution boards and the luminaires or slave converting kits shall be completed in MICC white LSZH sheathed cable.

27.2.1 Regulations

Emergency Lighting systems shall comply with the following:

- SI 2005/1541 Regulatory Reform (Fire Safety) Order 2005 (England And Wales only) or the relevant equivalent for devolved nations
- SI 2009/318 Health and Safety at Work etc. Act 1974 (Application to Environmentally Hazardous Substances) (Amendment) Regulations 2009 (UK Only)
- Local Building regulations
- Building Regulations Approved Document for England or the relevant equivalent for devolved nations

27.3 Performance Objectives

The intention of the system is to provide sufficient illumination to allow people to evacuate a building safely when the normal lighting has failed in an emergency situation.

To provide throughout all areas, as detailed on the drawings and in the specification, a complete emergency lighting installation to allow safe egress of the building in the event of circuits or total mains failure.

Emergency lighting shall also be provided as specified in areas where the use of the space provides an inherent danger to means of escape.

The emergency lighting system shall indicate clearly and unambiguously all escape routes; internally and externally as required, provide illuminance along such routes and immediate external areas of escape routes so as to allow safe movement towards and through all exits, ensure that the fire call points and firefighting equipment provided along escape routes can be located when the normal lighting has failed, and external escape routes are illuminated where specified with also Emergency Lighting to Open Areas for Anti Panic and Escape Lighting.

27.4 Design Parameters

All luminaires notated as emergency shall be ICEL approved whether detailed in the Schedule of Luminaires or not.

Emergency lighting is a generic term which covers a number of specific forms, which are identified with required design standards, which shall apply unless otherwise specified in this specification.

Emergency lighting systems shall comply with BS 9999, relevant parts of BS 5266, BS EN 50172, and, in sports venues, BS EN 12193.

27.4.1 Emergency Escape Lighting

This is provided to enable the safe exit should the normal supply fail. It consists of three forms:

- I. Defined Escape Route Lighting
This enables the safe exit of buildings and immediate external areas by the occupants by providing them with appropriate visual conditions and direction finding on escape routes and special locations. It ensures that the fire call points, firefighting equipment and safety equipment can be located and used.
Design Standard – 1 lux (min), operation in 5 seconds.

II. Open Area (Anti-Panic Area) Lighting

This is provided to reduce the chances of panic and enable the building occupants to move safely towards exit routes by providing them with appropriate visual conditions and direction finding. Design Standard – 0.5 lux (min), to defined areas, which excludes a border of 0.5m, operation in 5 seconds.

III. High Risk Task Area Lighting

This is provided to ensure the safety of those involved in possibly dangerous situations and processes and to allow the correct shut down procedures to be affected.

Design Standard – 10% of the required maintained illuminance for the task, but not less than 15 lux (min), operation in 0.5 second.

27.4.2 Type of System Operation

For the purpose of this specification the following emergency luminaire definitions shall apply:

- I. Standby Lighting – This is provided to enable normal activities to be continued should the normal mains supply fail.
- II. BS
- III. Non maintained – Luminaires containing one lamp which does not operate at all from the normal supply but will energise from the emergency supply upon failure of the normal circuit it monitors.
- IV. Maintained (Multi-Lamp) – Luminaires containing one or more lamps which operate from the normal switched supply as required and of which one will energise from the emergency supply upon failure of the normal circuit it monitors.
- V. Sustained (2 Lamps) – Luminaires containing two lamps, one of which operates from the normal supply (switched) at all times and the other which will energise from the emergency supply upon failure of the normal circuit it monitors.

The emergency lighting system shall be rated for 3-hour duration unless otherwise specified in this specification.

The emergency lighting system design and classification shall comprise one of the following types:

TYPE CODE	DESCRIPTION
X0[***]180 or Y0[***]180	Non-maintained, operation of the emergency lighting on failure of the normal supply or individual circuits, 3-hour operation.
X1[***]180 or Y1[***]180	Maintained operation of the emergency luminaires at all times, with 3-hour operation.
Xn[***]180 or Yn[***]180	Non-maintained and designated maintained, operation of the emergency lighting on failure of the normal supply or individual circuits and the addition of maintained emergency lighting at designated areas and exit locations, 3-hour operation

Where

- X denotes self-contained luminaires and wayfinder/escape signs
- Y denotes central battery-operated luminaires and wayfinder/escape signs
- N is a number between 2 and 5 defining the type of compound or combined maintained system in accordance with BS EN 5266-1
- [***] is used to denote facilities by inclusion of any or all of the following letters in order:

- A including test device
- B including remote test device
- C including inhibit mode
- D high risk task luminaire

27.5 Self-Contained Luminaires Systems

Self-contained luminaires shall comply with BS EN 60598-2-22.

Self-contained emergency wayfinding signs (emergency exit signs) shall comply with BS EN 5266-1, BS 5499 Series, BS EN 50172 and BS EN 60598-2-22.

The duration of the emergency luminaire output under emergency conditions shall be as indicated within the Schedule of Luminaires, 3-hour rating unless specified otherwise in this specification.

27.6 Central Battery Systems (Type X)

Luminaires used in this type of system derive their secondary supply via a central power source known as a Central Battery Unit.

The Central Battery Unit is to be of the type and rating designated in the Schedule of Equipment, and shall conform to the following:

PARAMETER	CRITEREA
Mode of Operation:	As desired within the Particular Specification (non-maintained/maintained/static-inverter/ups)
Lighting Load:	Load in Watts, as desired within the Particular Specification
Battery Type:	Low maintenance sealed lead acid
Input Voltage:	As desired within the Particular Specification (230 V, 50 Hz single- phase or 400 V, 50 Hz three-phase)
Output Voltage:	As desired within the Particular Specification (24v, 50v, 110v, 230v or 400v)
Duration:	3 hours unless specified otherwise in this specification.
Standard	BS EN 50171

The system shall incorporate:

- phase failure relays
- low electrolyte alarm
- sub-circuit monitor auxiliary contacts
- maintained lighting control switch
- solar dial time clock/24-hour timer
- earth fault alarm
- BS 764 automatic change-over contactor
- double pole HRC distribution fuses/double pole distribution circuit breakers/
- (automatic) timed boost
- timed delay test facility (auto-reset)
- run-on-timer
- appropriate means of isolation for all maintenance activities in accordance with the Electricity at Work Regulations 1989 and BS 7671
- remote alarm unit

- fire alarm interface relay (24v coil)
- auxiliary alarm relay

System indicators shall be provided, as a minimum, for:

- mains supply healthy
- mains supply fail
- float/boost
- charger or battery management system fail
- charger healthy.
- high volts
- low volts
- system fault

The system shall include a facility for remote monitoring to the Building Energy Management System (BEMS) or any other form of remote energy management system.

Install units of the AC inverter / battery type to provide maintained sine wave AC output suitable for the operation of fluorescent lamps etc. as indicated on the drawings and in this specification.

Provide the units in the positions indicated on the layout drawings complete with appropriate enclosure to contain all system equipment and controls etc.

The output shall feed either an integral distribution board or provide connection terminals as indicated in the specification.

The system Batteries shall provide operational time of 3 hours unless specified otherwise in this specification and a minimum life expectancy of 10 years for the Central Battery.

Provide monitoring of batteries to detect deficiencies and alarm to indicate such an event.

Delivery of batteries shall not be until the complete system is ready for test and adequate ventilation is available.

The intention is to ensure that batteries do not degrade during the construction stage of the works. Ensure that the batteries, when delivered, are new batteries set aside by the manufacturer for the project.

Central Battery System chargers to be capable of recharging batteries without manual adjustment within 24 hours following a rated discharge and be capable of recharging a completely discharged battery.

27.7 Periodic Testing

The emergency lighting shall be installed to enable testing by one or a combination of the following methods:

Type of testing:

1. Central test switch facility
2. Local test switches
3. Automatic emergency lighting systems monitoring and testing system

The equipment to be installed for the testing of the emergency lighting system shall comprise.

1. Key switches and contactor controls for central testing facility as set out on the schematic and layout drawings.
2. Local key switch controls suitably ganged as set out on the layout drawings.
3. Specialist emergency lighting automatic monitoring and testing system and installation.

Automatic Test Gear shall conform to BS EN 61347-2-7.

27.7.1 Key switch operation.

Unless specified otherwise, the emergency lighting key operated test switches local or central shall be wired to break the circuit live supply to switch off the normal lighting luminaires and operate the emergency lighting luminaires for test.

27.8 Switches

Supply and install all lighting switches, key switches and where specified control contactors for emergency lighting system testing, in the positions as indicated on the layout drawings and connect to the lighting final sub-circuit also indicated on the layout drawings and in accordance with the distribution board schedules.

It shall be the contractor's responsibility to check all door positions and swings at site prior to installation.

Supply and install lighting switches in areas where walls are plaster or tile etc. of the flush mounting type 20A rating, single pole rocker or key pattern assembly with cover plates to the finish indicated on the layout drawings and in the Schedule of Equipment.

Switches shall be capable of switching the full rated inductive or resistive load.

Supply and install lighting switches in plant rooms and other surface installation areas of the surface mounting metal clad type of the same manufacturer as used for flush types.

Each lighting switch is to be complete with rocker switch assembly, cover plate, pressed steel box and earthing fly lead.

Where more than one phase is present in a light switch box then phase barriers shall be installed.

Operation of the emergency lighting test switch shall switch off the normal circuit live supply and operate the respective emergency lighting luminaires for test.

28.0 General Power Outlets

28.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 1362v	Specification for general purpose fuse links for domestic and similar purposes (primarily for use in plugs)
BS 1363-1	13 A plugs, socket-outlets, adaptors and connection units. Specification for rewireable and non-rewireable 13 A fused plugs
BS 1363-2	3 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets
BS 1363-3	13 A plugs, socket-outlets, adaptors and connection units. Specification for adaptors
BS 1363-4	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A fused connection units switched and unswitched
BS 1363-5	13 A plugs, socket-outlets, adaptors and connection units. Specification for fused conversion plugs
BS 546 BS 456	Specification for plugs made of resilient material
BS 546	Specification. Two pole and earthing-pin plugs, socket outlets and socket outlet adapters.
BS EN 60309-1	Plugs, socket-outlets and couplers for industrial purposes. General requirements
BS EN 60309-2	Plugs, socket-outlets and couplers for industrial purposes. Dimensional interchangeability requirements for pin and contact-tube accessories
BS EN 60309-4	Plugs, socket-outlets and couplers for industrial purposes. Switched socket-outlets and connectors with or without interlock

28.2 General

All accessories including socket outlets, plugs fused connection units and double pole switches shall be supplied and installed in accordance with the type, size and finish indicated in other sections of the specification and as shown on the drawings.

All general-purpose socket-outlets shall be shuttered. 13 A sockets shall comply with BS 1363-2.

All round pin 2 A, 5 A and 15 A socket-outlets shall be shuttered and comply with the requirements of BS 546.

All industrial socket-outlets shall comply with BS EN 60309-1, BS EN 60309-2 and BS EN 60309-4, and shall have an IP rating of IP44 or IP67 appropriate to the environmental conditions in which they are to be used.

All socket-outlets shall be switched unless the contrary is stated in the specification and drawings.

All BS 1363-2 and BS 546 socket-outlets shall be complete with steel boxes of the same manufacture, complete with earth terminal.

For surface mounted positions such as plantrooms, electrical switchrooms etc., employing a surface mounted system of wiring, switched socket-outlets shall be surface mounted having metal front plates of an aluminium stove enamel finish mounted on matching metal boxes.

In external locations of areas subject to moisture, weatherproof socket-outlets and brass fixing screws shall be used.

For flush locations on plastered or equivalently finished walls, the socket-outlets shall have overlapping plates.

In any places where the finish is fair faced brickwork, the wiring shall be installed on the rear of the wall and shall make a back entry into the accessory. The socket-outlets shall be neatly recessed into the brickwork and shall incorporate an overlapping plate.

Socket-outlets shall be fixed by a minimum of 2 No. number 10 screws and plastic type plugs fitted into suitably sized holes drilled into the structure.

28.3 Wiring

All final circuit accessories shall be circuited as indicated on the drawings and in the schedules. The minimum size of conductor for ring type circuits shall be 2.5 mm².

Where a conduit system is used, the separate circuit protective conductor shall be terminated directly in the appropriate terminal on the socket outlet along with a 4 mm² green-and-yellow insulated bonding connection to the earth terminal in the metal box.

Where the assembly does not provide a reliable electrical contact between the cover plate and box with effective connection of metal operating bars and toggles, then an insulated earthing lead shall be provided solidly connected to the metal plate and operating bar or toggle and terminating at the fixed earthing terminal incorporated in the associated box.

28.4 Plugs (Socket Outlets)

All plugs shall be of moulded rubber or other resilient material complying with BS 1363 or BS 546 and PD 4007 Supplement No 1. The plugs shall have internal cord grip. Shields and/or insulation shall be fitted to prevent live pins being touched when the plug is being inserted. 13 A plugs to BS 1363-2 shall be fitted with cartridge fuse links to BS 1362. The fuse rating shall be selected to give protection to the flexible cord or cable connected, or in accordance with the appliance manufacturer's instruction.

Industrial plugs, appliance inlets, appliance connectors (socket-outlets) and fixed socket-outlets shall have a polycarbonate enclosure and brass conducting pins. with ingress protection rating IP44 or IP67 as appropriate to the environmental conditions prevalent. The enclosure shall match the industrial socket-outlet or plug and be in full accordance with BS EN 60309-2 and BS EN 60309-4 as appropriate.

28.5 Fused Connection Units

Units shall be flush or surface mounted, switched or unswitched with or without neon indicator and flex outlet as specified and of same finish and type as the socket outlets in the same area.

Front plates shall be engraved to indicate the equipment served.

Switched fused connection units shall comply with BS 1363-4 and shall be of the type which does not expose live metal parts when the fuse holder is opened for replacement of fuse.

Switched fused connection units shall be fitted with a BS 1362 fuse of the correct rating to protect the appliance and wiring served. Manufacturer's instructions for appliances or items of electrical equipment shall be followed where they specify sizes, types, or ratings of protective device, unless otherwise agreed with the Engineer.

29.0 Building Expansion Joints

29.1 General

Routes of electrical services, cables, conduits, trunkings and cable trays etc., shall be so designed to avoid crossing buildings expansion joints if at all possible. Under no circumstances will conduits and cables encased in the building fabric or floor screeds etc., be allowed to cross a building expansion joint.

Where it is unavoidable for surface cables and support systems to cross an expansion, a sufficient loop of cable must be allowed between fixings of cables fixed directly to the building structure.

A proprietary expansion joint shall be fitted to any conduit and trunking run as described in the appropriate sections of this specification.

30.0 Methods of Fixing

30.1 General

Ensure that every fixing installed is adequate to support and/or restrain the item of plant or equipment concerned, making all necessary allowance for the fixing and for the substance into which it is anchored or fixed.

30.2 Accessories and Lightweight Equipment

Lightweight equipment, accessories and conduit saddles shall be fixed to brick or concrete structures by means of sheradised screws in white metal, bronze or plastic plugs. Round head screws shall be used where fixings occur inside accessory boxes.

Wherever possible fixings to brickwork shall be made in the bricks and not in the seams. Fixing to enclosed hollow structures of soft or hard fibre boards etc., shall be made using proprietary spring or gravity toggles. Under no circumstances shall such fixing methods be used in plasterboard or materials of a like nature, unless first approved by the Engineer.

Fixings to timber shall be made using steel woodscrews. Galvanised steel, brass or cadmium plated steel screws shall be used.

Lightweight equipment installed on a mild steel sheet structure shall be fixed by an appropriately sized set screw and must be complete with plain and serrated or spring washer.

Fixings to heavy gauge or cast metal shall be made using machine head screws entered into tapped holes. Tapped threads shall be achieved using the correct drill size with taper, second and plug taps.

Screws with damaged threads and/or damaged heads shall be replaced.

30.3 Heavyweight Equipment

Fixings to brick and concrete shall be made using an approved expanding bolt suitably sized and entered into a pre-drilled hole of depth (exceeding plaster thickness) equal to the length of fixing to be used.

The threaded section of an installed expanded bolt fixing shall protrude through the equipment fixed, to enable a nut, plain and serrated or spring washer to be fixed leaving a minimum of 4mm of thread exposed.

Fixings to brickwork shall be made in the bricks and not in the seams. In items of equipment containing multiple fixing provisions where it is impossible to make all fixings in the brickwork, then the equipment shall be positioned to enable the upper fixings to be made in the brick.

Fixings may also be achieved in concrete structures by pre-casting or grouting rag bolts.

Equipment installed on a heavy wooden structure may be fixed using coach screws entered into correctly sized pre-drilled pilot holes.

Fixing heavy equipment to metal framework and other substantial structures shall be made using steel set screws or bolts with nuts, plain and serrated or spring washers.

Heavy equipment shall not be fixed by plugs or shot bolts without the written approval of the Engineer, nor shall any structural steelwork or support be drilled or cut without this approval.

In all cases where fixings, bracket work and other metal supports are exposed to the weather or damp or hostile conditions, they shall be suitably treated with an inhibiting substance or galvanised in accordance with the Specifications or as directed by the Engineer. Under no circumstances will rusted metalwork be installed.

Fixing adapters and brackets or patented approved fixings to steelwork shall be manufactured from mild steel and be of a minimum thickness of 4mm.

30.4 External Entries

Where cables, conduits or trunkings exit from the interior of a structure to the exterior sufficient provision shall be made to prevent the ingress of water penetration to the structure from the cabling system.

Singular cables that enter the structure from a higher level shall be complete with a drip loop to enable the water to be deposited from the cable prior to entering the building.

Cable trays, conduits and trunkings that enter the structure from a higher level shall be complete with a 'set-up' from the elbow or bend to provide a facility to enable the water to be deposited from the cable prior to entering the building.

31.0 Miscellaneous Three-Phase and Single-Phase Power

31.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671/A1	Requirements for electrical installations

31.2 General

Where an item of electrical equipment is located remotely from the source of control, an isolating switch, breaking all live conductors and suitably sized to suit the equipment served, shall be mounted as near to the equipment as practicable.

The isolating switch shall be in accordance with the current edition of BS 7671/A1.

Where an item of equipment contains multiple line connections or an electric motor operates on assisted start, e.g. star-delta, a multiple pole isolator, having a pole for each line feed, shall be located adjacent to the motor or electrical equipment to isolate the starter coil circuit, each line conductor and override the starter or control equipment automatic circuits. Start, re-set and other such controls integrated into starters or control panels shall be rendered inactive by the operation of the remotely located isolator. The isolating switch shall be in accordance with the current edition of BS 7671/A1.

32.0 Termination at Fixed Equipment

32.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7671/A1	Requirements for electrical installations

32.2 General

In a conduit installation where the final control equipment is remotely located from the electrical apparatus being served, a conduit link shall be installed from the control equipment to terminate adjacent to the apparatus in a fixed through conduit box complete with lid.

Flexible conduit shall connect the conduit box with the apparatus in accordance with Section 15 of this part of the specification with particular emphasis on the correct method of earthing as required by the current edition of BS 7671.

Cables serving the electrical apparatus shall be continuous throughout their length, passing unbroken through the conduit box and flexible conduit. Connectors fitted inside the conduit box will not be permitted unless so directed by the Engineer.

Ensure that every item of equipment is provided with terminals of adequate size to permit the connection of the conductors specified.

33.0 Wiring Accessories

33.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 1363-2	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A switched and unswitched socket-outlets
BS 1363-4	13 A plugs, socket-outlets, adaptors and connection units. Specification for 13 A fused connection units switched and unswitched
BS 4177	Specification for cooker control units
BS 4662	Boxes for flush mounting of electrical accessories. Requirements and test methods and dimensions.
BS 5733	Specification for general requirements for electrical accessories
BS 8300-1	Design of an accessible and inclusive built environment. External environment. Code of practice
BS 8300-2	Design of an accessible and inclusive built environment. Buildings. Code of practice
BS EN 60670-1	Boxes and enclosures for electrical accessories for household and similar fixed electrical installations. General requirements

33.2 Location of Equipment, Luminaires and Accessories

Proposed positions for equipment, luminaires and accessories are detailed on the drawings; the final location for equipment shall be determined on site and be dictated by the full co-ordination of all other works on site.

Ensure that the latest and current drawings are being worked to in respect to architectural layouts, builders' works, and electrical and mechanical services.

The engineer reserves the right to move equipment and wiring accessories by a 1.5 m radius from the locations detailed on the drawings prior to the works being carried out.

Mounting heights of switches, socket-outlets and controls shall comply with BS 8300-1 and BS 8300-2, or as required by the Building Regulations Approved Document for England or the relevant equivalent for devolved nations. Unless otherwise detailed the following mounting heights shall apply and are in respect to finished floor level:

ITEM	MOUNTING HEIGHT
Lighting switches:	1100 mm to centre
Thermostats:	1500 mm to centre
Bell pushes:	1100 mm to centre
Fire alarm break glass contacts:	1100 mm to centre

ITEM	MOUNTING HEIGHT
Fire alarm sounders:	100 mm (below suspended/solid ceilings to top) or 2600 mm above finished floor level to underside
Socket outlets:	450 mm to underside or 50mm above finished skirting, whichever is the greater. (or 150 mm above work surface to underside) (min. 350 mm to corner wall)
Connection units:	450 mm to underside (or 150 mm above work surface to underside) (min. 350 mm to corner wall)
Distribution boards:	1800 mm to top

All groups of accessories shall be in line either vertically or horizontally or as detailed on the drawings.

Where groups of equipment are to be installed in the same location the Contractor shall submit a detailed drawing of the proposed arrangement, to the Engineer, for approval prior to work commencing.

33.3 Luminaires

Provide light fittings as the type, dimension and manufacture as detailed within the schedules and on the drawings. They shall be supplied as a luminaire suitable for its intended use with all accessories attached when installed.

Provide a sample luminaire at the engineer's request with at no cost prior to the order for the full quantity of luminaires.

33.4 Lighting Switches

Provide lighting control switches in the positions shown at 1100 mm AFFL to centre unless otherwise detailed. Switches shall be located at least 200 mm from any architrave.

Where more than one switch is to be provided in a single location then a multi-gang mounting enclosure shall be used. Switch fascia's of 4-gang enclosures and above shall be labelled to identify their purpose with respect to the zones/arrays being controlled. The exact text shall be confirmed to the engineer prior to being engraved.

Provide a proprietary mounting box that incorporates phase barriers where polyphase situations are likely to occur within the same enclosure. Label the interior of each enclosure where a polyphase situation is present. Each switch that accommodates different phases shall be clearly identified on the as fitted drawings.

Switches shall be connected to provide the control shown on the drawings or within the particular specification.

Emergency lighting test switches shall be double pole key operated and contained with the same switch enclosure as the general lighting switch. The switch shall be engraved to denote the test and normal positions. All spare keys shall be handed to the engineer upon completion of the works.

33.5 Time Switches

Unless otherwise detailed provide a quartz synchronous plug-in type self-starting and self-winding timed switch in the positions shown on the drawings and in accordance with the schedules.

As a minimum, each time switch shall comprise the following functions;

- ON / OFF / Manual switch positions
- Program facility to de-select days
- 24-hour display
- 2 ON and 2 OFF functions in a single day
- Reserve for 30 hours

33.6 Socket-Outlets & Fused Connection Units

Where fixed equipment is being provided under the contract provide a plug with a fuse rated to the manufacturer's recommendations to enable the equipment to be connected to the designated socket-outlet associated with the electrical installation.

Unless otherwise detailed connection units/outlets shall be mounted adjacent to the equipment being served and. The fuse at the connection unit, or upstream protective device where the connection unit is unfused, for example for cooking appliances, shall be rated in accordance with the equipment manufacturer's recommendations.

Unless otherwise detailed socket outlets shall be mounted as stated in Clause 32.2.

Ensure that the terminals of the outlets will accept the number and cross-sectional areas of conductors being used prior to ordering the accessories.

All socket-outlets and fused connection units shall be mounted onto a suitable proprietary manufactured mounting box that is specific to the range of sockets being provided. Socket-outlets to BS 1363-2, fused connection units to BS 1363-4, and cooker control units to BS 4177 shall be mounted onto mounting boxes in accordance with BS 1363, BS 4177, BS EN 60670-1, BS 4662 and BS 5733 as appropriate.

Where socket-outlets are detailed for mounting onto trunking they shall be mounted using manufacturer's proprietary mounting plates that are compatible with the socket-outlet and also the trunking system.

34.0 Fire Alarm Systems

34.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 5839-1	Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises
BS 5839-3	Specification for automatic release mechanisms for certain fire protection equipment
BS 5839-6	Code of practice for the design, installation and maintenance of the fire detection and fire alarm systems in dwellings
BS 6387	Specification for performance requirements for cables required to maintain circuit integrity under fire conditions
BS 9999	Code of practice for fire safety in design, management and use of buildings.
BS EN 14604	Smoke alarm devices
BS EN 50130-4	Alarm systems. Electromagnetic compatibility. Product family standard: Immunity requirements for components of fire, intruder, hold up, CCTV, access control and social alarm systems
BS EN 50130-5	Alarm systems. Environmental test methods
BS EN 50134	Alarm systems – social alarm systems
BS EN 54-11	Fire detection and fire alarm systems. Manual call points
BS EN 54-2	Fire detection and fire alarm systems – control and indicating equipment
BS EN 54-4	Fire detection and fire alarm systems. Power supply equipment
BS EN 54-series	Fire detection and fire alarm systems
BS EN 60079	Electrical apparatus for explosive gas atmospheres
BS ISO 7240-15	Fire detection and alarm systems. Point-type fire detectors using smoke and heat sensors

34.2 General

The type and designation of the fire alarm system is defined within the particular specification.

Unless detailed otherwise the installation shall comply with relevant parts of BS 5839 and relevant parts of BS EN 54.

Areas designated as being an explosive atmosphere hazardous area shall be installed with equipment, wiring and accessories that are compliant with BS EN 60079.

Where end of line elements are required to provide for a complete installation they shall be of the type and installed to manufacturer's recommendations.

The complete installation shall operate as an integrated system.

Equipment and components shall be stored, handled and installed in accordance with relevant parts of BS 5839 and the respective component manufacturer's recommendations.

34.3 Existing Installations

Where the work involves extensions or modifications to existing systems a method statement shall be prepared that describes how coverage can be maintained in the existing areas throughout the works.

34.4 Cable & Wiring installation

The cable installation shall be planned and co-ordinated with all other services prior to commencing installation. These routes shall be detailed on the working drawings. Fire alarm sounder circuits shall be wired and cabled using a fire-resistant cable that conform to the CWZ classifications of BS 6387 and shall be in accordance with relevant parts BS 5839.

34.5 Trigger Devices

Unless otherwise detailed trigger devices shall comprise manually operated break glass units, smoke sensors/detectors, heat sensors/detectors, duct probes and sprinkler valve sensors.

Manually operated break glass units shall be mounted as detailed within the schedules and be in accordance with BS EN 54-11, BS EN 50130-4 and BS EN 50130-5. Each break glass unit shall incorporate an anti-fragmentation film and respond once activated within the time detailed within BS 5839.

Unless otherwise detailed, all automatic fire sensors and detectors shall be compliant with BS EN 50134-4, BS EN 50130-5, BS 54 parts 5, 7, 8, 10, 20, 28, 29,30, 31, and BS ISO 7240-15 and be of the same manufacturer and compatible with the system being installed. They shall comprise a plug-in type mounting base that is common to all detector/sensors being installed and provides a visible means of indicating that it has been activated.

Where trigger devices are installed in concealed zones, risers, floor voids and ceiling voids etc. then a remote visible indicator shall be installed. The type and location shall be as defined within the schedules and on the drawings.

34.6 Alarm Systems

Provide sounders and electric door détentes and relays to operate in the event of a trigger device being activated in accordance with the scope of works and drawings.

Sounders shall be in accordance with BS EN 50130-4 and BS EN 50130-5 of the type and mounting arrangements as detailed within the schedules and drawings.

Release mechanisms and relays systems shall be compliant with BS 5839-3, BS EN 50130-4 and BS EN 50130-5 and be installed in the locations shown on the drawings. The type of mechanism shall be as detailed within the schedules or drawings.

Provide strobe beacons in accordance with relevant parts of BS 5839, BS EN 50130-4, BS EN 50130-5 and BS EN 54-2 where high ambient noise levels are to be encountered

34.7 Loop Isolators & Zone Monitoring

Provide isolation modules at the entry and/or exit from each separate area of a designated fire zone as shown on the drawings. As a minimum isolation modules shall be provided to ensure that no more than

2,000 m² of covered area becomes unprotected in the event of any single cable fault and no more than 10,000 m² of covered area becomes unprotected in the event of any two simultaneous cable faults, all in compliance with BS 5839-1.

Designated loop isolators shall also provide for monitoring the zone status as shown on the drawings.

Modules shall comply with BS EN 50130-4, BS EN 50130-5 and BS EN 54-2.

34.8 Fire Control Panel

Provide a main fire control panel in the location and of the type shown on the drawing and detailed within the schedules.

Each fire panel shall be supplied from an adjacent isolating accessory as detailed with the particular section of the specification.

The functions to be afforded by the panel are detailed within the respective schedules.

The fire panel shall be compliant with BS 5839-1, BS 5839-6 and BS EN 54-2, BS EN 50130-4, BS EN 50130-5, BS EN 54-4.

34.9 Repeater Control Panel

Where detailed, provide a repeater panel in compliance with BS EN 54-4, BS EN 54-2, BS EN 50130-4 and BS EN 50130-5 in the location and of the type detailed within the schedules.

The functional requirements of the repeater control panel are detailed within the respective schedules.

34.10 Mimic Panel

Provide a mimic panel of the system adjacent to the main fire control panel and also the repeater control panel in accordance with BS EN 50130-4, BS EN 50130-5 and BS EN 54-2.

As a minimum the mimic panel shall detail the respective zones. The exact requirements for the mimic panel are detailed within the particular section of the specification.

34.11 Remote Signalling

Where detailed provide a facility for the fire control panel to communicate to a remote station.

34.12 Record Drawings and Operating Instructions

Provide the system user and owner with a logbook and certificate of installation and commissioning in accordance with BS 5839-1.

Prepare and provide record drawings that show the location of the equipment and accessories related to the fire alarm system.

A schematic diagram shall be a requirement as part of the record drawings

All of the above information shall be contained within the Operating and Maintenance manuals prior to completion of the project.

35.0 Radio and Television Systems

35.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6259	Code of practice for the design, planning, installation, testing and maintenance of sound systems.
BS 6513-series	Wideband cabled distribution systems
BS 7587, IEC 61022	Specification for interconnection of radio and TV receivers to feeder systems outlet
BS EN 50561-1	Power line communication apparatus used in low-voltage installations.
BS EN 55032	Electromagnetic compatibility of multimedia equipment. Emission requirements
BS EN 55035	Electromagnetic compatibility of multimedia equipment. Immunity requirements
BS EN 60728-11	Cable networks for television signals, sound signals and interactive services. Safety
BS EN 61000-3-2	Electromagnetic compatibility (EMC)
BS EN 61000-3-3	Electromagnetic compatibility (EMC). Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems.
BS EN 61938, IEC 61938	Audio, visual and audio-visual systems. Interconnections and matching values. Preferred matching values of analogue signals
BS EN 62305-3	Protection against lightning. Physical damage to structures and life hazard
BS EN 62305-4	Protection against lightning. Electrical and electronic systems within structures
BS EN 62368-1	Audio/video, information and communication technology equipment. Safety requirements

35.2 General

Provide a system as detailed on the drawings, specification, within the schedules and as detailed below. In all instances the system and its elements shall be in accordance with the manufacturer's recommendations and BS 6259 and BS EN 60728-11 where applicable.

Equipment shall comply with the safety requirements of BS EN 60728-11, BS EN 62368-1, and the EMC requirements of BS EN 55032, BS EN 55035, BS EN 50561-1, BS EN 61000-3-2, and BS EN 61000-3-3. Equivalent harmonized standards may be acceptable if approved by the Engineer.

Unless otherwise detailed and where required, engage a specialist to undertake the design development, supply, installation, commissioning and setting to work any of the following systems as required.

Where a high frequency distributed sound and vision system is required the programmes shall be selected to operate between the frequency band range of 3 MHz and 30 MHz.

The HF system shall be cables using balanced pair or star quad cables.

Where VHF/UHF distribution systems are to be used then the system shall be designed to operate between 40 MHz and 860 MHz.

Where a wideband cabled distribution system is required then the system shall comply with BS 6513 and BS EN 60728-11.

Where an audio-visual system is required then the system interfaces shall be in accordance with BS EN 61938 and IEC 61938.

Where specified, provide an interconnecting domestic digital Bus (D2B) to integrate and connect any audio and video cluster, as well as the home electronics in accordance with BS EN 61983.

All aerials shall be installed in accordance with BS EN 61983, IEC 61938 and bonded to the buildings lightning protection system in accordance with BS EN 62305-3 and BS EN 62305-4 as detailed within Section 2 of this document.

All radio and television receivers that are to be provided shall be connected to the feeder system outlets in accordance with BS 7587, IEC 61022.

Upon completion of the installation a demonstration of the system(s) shall be carried out to verify its operations and that the specified requirements are being achieved. The quality of the system shall demonstrate to shown that the sound and visual output to the users is not impaired.

36.0 Security Systems

36.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 7958	Closed circuit television (CCTV). Management and operation. Code of practice.
BS 8300-2	Design of an accessible and inclusive built environment. Buildings. Code of practice
BS 8418	Installation and remote monitoring of detector-activated CCTV systems. Code of practice.
BS EN 50131	Alarm systems. Intrusion systems
BS EN 50131-1	Alarm systems. Intrusion and hold-up systems. System requirements.
BS EN 50134-series	Alarm systems. Social alarm systems
BS EN 50136	Alarm systems. Alarm transmission systems and equipment
BS EN 60529	Degrees of protection provided by enclosures
BS EN 60839-series	Alarm and electronic security systems.
BS EN 62676-4	Video surveillance systems for use in security applications. Application guidelines
BS EN 62676-series / BS EN IEC 62676-series	Video surveillance systems for use in security applications
BS EN ISO 11064-series	Ergonomic design of control centres
PD CLC/TR 50456	Guidelines for achieving compliance with EC directives for Alarm Systems

36.2 Intruder, Social Alarm & Door Access

Provide a system as detailed on the drawings, specification, within the schedules and as detailed below. In all instances the system and its elements shall be in accordance with the manufacturer's recommendations and BS EN 50131-1, relevant parts of BS EN 50131, relevant parts of BS EN 62676 / BS EN IEC 62676, relevant parts of BS EN 60839, relevant parts of BS EN50134, relevant parts of BS EN 50136, and PD CLC/TR 50456 where applicable.

Unless otherwise detailed and where required, engage a National Security Inspectorate (NSI) Gold Scheme recognised specialist to undertake a survey in accordance with BS EN 50131 and relevant NSI codes and standards, the design development, supply, installation, commissioning and setting to work the Intruder, Social Alarm and Door Access systems as required.

Provide all Operating and Maintenance records and test schedules as identified within the relevant British Standard and relevant NSI approved codes and standards.

Provide the preparation of all paperwork should the client wish to undertake a maintenance contract with the system maintainer.

36.3 CCTV

Provide a system as detailed on the drawings, specification, within the schedules and as detailed below. In all instances the system and its elements shall be in accordance with the manufacturer's recommendations and BS 7958, BS 8418, relevant parts of BS EN 62676 / BS EN IEC 62676, and applicable NSI codes and standards.

Unless otherwise detailed and where required, engage a NSI Gold Standard recognised specialist to undertake a survey in accordance with BS EN 62676-4 and relevant NSI codes and practices, the design development, supply, installation, commissioning and setting to work any the following systems as required.

Monitors and control equipment installed in security control rooms shall be located to comply with BS 8300-2 and relevant parts of BS EN ISO 11064.

Exterior cameras shall be protected against ingress of dust and moisture to at least BS EN 60529 IP65. Where specified, vandal-resistant enclosures shall be provided.

The system shall be installed and commissioned in accordance with relevant NSI approved codes and standards, and BS EN 62676-4.

37.0 Fire Barriers

37.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 9999	Code of practice for fire safety in the design, management and use of buildings.

Where electrical services pass through the fabric of the building the fire integrity of the fabric shall be maintained at all times.

The Contractor shall include for supplying and installing new fire barriers within all trunking, bus bars and ducts passing through wall, soffit, floors, or any other fire compartmentation. The fire barriers shall be as manufactured by Dufaylite Developments Limited, their "Fireblock" range or equal and approved, shall accord with the requirements of the local regulations and the fire rating of the barrier crossed.

Where cables pass through the building fabric, wall and floors flush mounted cable transits as manufactured by Messrs Hawke Cable Gland Limited or equal and approved shall accord with the requirements of the local regulations and the fire rating of the barrier crossed.

The transit frames shall be supplied by the Contractor and be built into the structure.

The Contractor shall supply and install the fire rated cable barrier insert blocks to suit the number and size of cables passing through the particular hole. 30% spare area in the frame shall be provided and shall be fitted out by utilising 'spare blocks'. The Contractor shall supply 30% spare insert blocks of each size utilised. These shall be handed to the Engineer prior to commencement of commissioning.

Where underground cables pass through fire rated walls/ground beams/slabs, the Contractor shall make good with fire rated cable transits to ensure that there is no ingress of water to 10 bar and 2-hour fire rating.

38.0 Off-Site Painting & Anti-Corrosion Treatment

38.1 General Requirements

Where particular methods of finish and painting are not specified, ensure following requirements are met.

Protect all metal work, plant, equipment, pipelines, ductlines, ancillaries, brackets and supports against corrosion and oxidation.

Provide ferrous metals, machined or otherwise with protective coatings at manufacturer's works.

Ensure all items requiring on-site decorative finishes are provided primed to suit base material and required finish.

38.2 Damaged Finishes

Following delivery to site, storage on site and installation make good any damage to finishes, by cleaning, degreasing and refurbishing.

38.3 Paint Materials

Use the following materials as appropriate:

- Solvent borne priming paint for bare woodwork.
- Red oxide priming paint for bare iron and steelwork.
- Zinc chromate priming paint for bare ferrous and non-ferrous metals.
- Calcium plumbate priming paint for galvanised steel or composite wood/metal components.
- Undercoating paint for previously primed or painted surfaces before the application of finishing coats.
- Gloss finishing paint for previously primed or painted/undercoated surfaces.
- Epoxy resin paint for specialist coatings requiring resistance to acids, alkalis, oils, solvents, abrasion or high humidity.
- Aluminium paint for structural steelwork, storage vessels, heated metallic surfaces and similar applications where moisture and heat resistant properties are required.
- Cold galvanising paint for making good damage to previously galvanised surfaces and protection to galvanised materials modified during installation.
- Zinc-rich metallic paint for bare iron and steelwork where electrical conductivity has to be assured.
- Black tar-based paint for moisture resistant protection to metal surfaces where decorating appearance is not important.
- Bitumen based coatings for cold application to protection to iron and steel, particularly pipelines and fittings for use in contact with potable water.

Bitumen based coatings for cold application to not be used in contact with potable water.

38.4 Paint Quality

Ensure paints used are of quality and type to suit application and that primers have good adhesion, covering power, rust-inhibiting and grain filling properties; gloss finishing paints are of machine finish grade having high adhesion and high resistance to solvents, mineral oils, cutting oils, detergents, chipping and impact damage.

38.5 Heat Resistant Paint

Use heat resistant paints for applications to surfaces over 80°C.

38.6 General

Ensure paints are applied in accordance with manufacturer's instructions.

38.7 Weather and Other Conditions

Do not apply paints where weather, temperature, humidity or other conditions may have a damaging effect upon finish or paint.

38.8 Cleaning

Ensure metal surfaces are thoroughly cleaned, all mill and weld scale removed and finally degreased.

38.9 Application Off-Site

Wherever possible ensure paint finishes applied by component manufacturers are spray applied.

38.10 Application

Apply paint evenly and ensure finish shows no excessive brush marks, grinning, runs, sagging, ropiness or other application defects.

38.11 Cold Galvanising

Repair damage to galvanised components due to installation process, i.e., following cutting, drilling or welding, by applying 2No substantial coats of cold galvanising paint.

38.12 Protection of Bright Machine Parts

Apply a protective coating to all bright machined parts before despatch from works.

Do not remove protective coatings unless required for installation, testing or commissioning purposes and in such cases reinstate upon completion.

Repair any damaged protective coating or bright machined part, or where necessary replace damaged component.

Use and apply metal coatings in accordance with manufacturer's instructions.

Complete where possible all welding, drilling, bending and other work before metal coating.

39.0 Electromagnetic Compatibility (EMC)

39.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6701	Telecommunications equipment and telecommunication cabling. Specification for installation, operation and maintenance.
BS 7671	Requirements for Electrical Installations
BS EN 50121-1	Railway applications. Electromagnetic compatibility.
BS EN 50121-4	Railway applications. Electromagnetic compatibility. Emission and immunity of the signalling and telecommunications apparatus
BS EN 50174-1	Cabling Installation. Installation specification and quality assurance
BS EN 50174-2	Cabling Installation. Installation planning and practices inside buildings
BS EN 50174-3	Cabling Installation. Installation planning and practices outside buildings
BS EN 50310	Telecommunications bonding networks for buildings and other structures
BS EN 61000-6-3	Electromagnetic compatibility (EMC). Generic standards. Emission standard for residential, commercial and light-industrial environments
BS EN 61000-6-5	Electromagnetic compatibility (EMC). Generic standards. Immunity for equipment used in power station and substation environment
BS EN 61000-6-7	Electromagnetic compatibility (EMC). Generic standards. Immunity requirements for equipment intended to perform functions in a safety-related system (functional safety) in industrial locations
BS EN IEC 61000-6-1	Electromagnetic compatibility – Generic immunity standards. Immunity standard for residential, commercial and light-industrial environments
BS EN IEC 61000-6-2	Electromagnetic compatibility (EMC). Generic standards. Immunity standard for industrial environments
BS EN IEC 61000-6-4	Electromagnetic compatibility (EMC). Generic standards. Emission standard for industrial environments
BS IEC 61000-5-2	Electromagnetic compatibility (EMC). Installation and mitigation guidelines. Earthing and cabling
BS IEC 61000-6-6	Electromagnetic compatibility (EMC). Generic standards. HEMP immunity for indoor equipment

STANDARD	TITLE
DD IEC/TS 61000-5-8	Electromagnetic compatibility (EMC). Installation and mitigation guidelines. HEMP protection methods for the distributed infrastructure

Provide and install the complete electrical installation to comply with the Electromagnetic Compatibility Regulations 2007, and subsequent amendments, together with associated acts and statutory instruments.

The electromagnetic disturbance generated by the selected systems and equipment are not to exceed a level allowing other systems and equipment to operate as intended.

Select, locate and arrange sensitive cabling, and equipment, such as those from so that they are adequately separated from, and sufficiently clear of, power equipment, systems, and cabling, for no adverse influences to arise.

Provide Ensure installation methods incorporate suitable EMC mitigation measures, including metallic screening to protect susceptible parts of the facility, systems and equipment from disturbances which could cause disruption to operations, affect safety-related or life safety critical systems and equipment, or cause damage to equipment or installations.

Ensure that records of installation practices and mitigation measures used to achieve compliance with relevant legislation and standards, are maintained throughout design, installation and commissioning, and are provided in operation and maintenance information.

39.2 Design Parameters

Zoning to manage EMC environments shall align with the CENELEC harmonized standards approach as follows:

- (a) Domestic, commercial and light industrial environment
 - i) Emissions BS EN 61000-6-3
 - ii) Immunity BS EN 61000-6-1
- (b) Industrial environment
 - i) Emissions BS EN 61000-6-4
 - ii) Immunity BS EN 61000-6-2
 - iii) Immunity for safety-related systems and their components BS EN 61000-6-7
- (c) Power station or substation environment
 - i) Emissions BS EN 61000-6-5
 - ii) Immunity BS EN 61000-6-5
 - iii) Immunity for safety-related systems and their components BS EN 61000-6-7
- (d) Additional requirements for high altitude electromagnetic pulse (HEMP) immunity
 - i) Indoor installations BS IEC 61000-6-6
 - ii) Distributed infrastructure installations DD IEC/TS 61000-5-8
- (e) Additional requirements for railway environment
 - i) Fixed power supply installations, BS EN 50121-1 and BS EN 50121-5
 - ii) Railway signalling and telecommunications installations, BS EN 50121-1 and BS EN 50121-4

All electrical equipment and systems shall comply with the relevant BS, BS EN or other EMC product specific standards and where no product specific standards are available they shall comply with the generic standards

suitable for the particular environment in which the equipment is to operate relevant to the EMC environment listed above.

Careful attention is to be given to the locations selected for initial and future power, data and control equipment and distribution routes, to ensure that data systems are not adversely affected by electromagnetic interference from power systems.

The installation shall be designed and installed taking into account good EMC practices of relevant standards including but not limited to BS 7671, BS 6701, BS IEC 61000-5-2, BS EN 50310, BS EN 50174-1, BS EN 50174-2, BS EN 50174-3.

Ensure that areas intended for general occupation and use, do not exceed the indirect-effect action levels and exposure limit values mandated in the Control of Electromagnetic Fields at Work Regulations 2016.

Ensure that the following are clearly identified in the Operation and Maintenance Manual and where appropriate the Health and Safety File:

- All areas where the indirect-effect action levels and exposure limit values may be exceeded, and any relevant precautions, safe methods of work and personal protective equipment, that apply to those areas.
- All operations and maintenance activities that may exceed the exposure limit values and/or indirect-effect action levels, along with recommended safe methods of work and personal protective equipment required.
- All areas where electromagnetic fields exist that may affect employees at particular risk, including users of active and passive implanted medical devices, body worn medical devices or as a result of pregnancy.

39.3 System Equipment

All items of electrical equipment installed shall comply with the Electromagnetic Compatibility Regulations 2016 and shall carry the 'CE' mark.

As part of the operation and maintenance information, provide a declaration of conformity for each relevant item of equipment, with details of the means by which the manufacturer or importer declares conformity, detailing either the relevant EMC standards by which the declaration is made for electromagnetic compatibility, or a declaration of the EMC environment aligned to the CENELEC approach for which the equipment is deemed suitable.

Provide separate cable containment systems for controls and other signal cabling as described elsewhere in this document.

40.0 Inspection, Testing and Commissioning

40.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
	IET Code of Practice for Electric Vehicle Charging Equipment Installation
	IET Code of Practice for Electrical Energy Storage Systems
	IET Code of Practice for Grid-Connected Solar Photovoltaic Systems
APEA / EI 'Blue Book'	Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4 th Edition.
BS 5266-1	Emergency lighting. Code of practice for the emergency lighting of premises
BS 5839-1	Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises
BS 7430	Code of practice for protective earthing of electrical installations
BS 7671/A1	Requirements for electrical installations
BS 7698-12, ISO 8528-12	Reciprocating internal combustion engine driven alternating current generating sets. Emergency power supply to safety devices
BS EN 1838	Lighting applications. Emergency lighting.
BS EN 50191	Erection and operation of electrical test equipment.
BS EN 50310	Telecommunications bonding networks for buildings and other structures.
BS EN 50522	Earthing of power installations exceeding 1 kV a.c..
BS EN 60079-series	Explosive atmospheres.
BS EN 61010-031	Safety requirements for electrical equipment for measurement, control and laboratory use. Safety requirements for hand-held probe assemblies for electrical measurement and test
BS EN 61010-1	Safety requirements for electrical equipment for measurement, control, and laboratory use. General requirements
BS EN 61243-series	Live working. Voltage detectors
BS EN 61557-series	Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. Equipment for testing, measuring or monitoring of protective measures.
BS EN 61936-1	Power installations exceeding 1 kV a.c. Common rules
BS EN 62271-200	High-voltage switchgear and controlgear. AC metal-enclosed switchgear and controlgear for rated voltages above 1kV and up to including 52 kV
BS EN 62305-series	Code of practice for protection of structure against lightning
BS EN 62446-1	Photovoltaic (PV) systems.

STANDARD	TITLE
BS EN ISO/IEC 17025	General requirements for the competence of testing and calibration laboratories.
BS ISO 8528-series	Reciprocating internal combustion engine driven alternating current generating sets
ENA Engineering Recommendation G100/1	Technical requirements for customer export limiting schemes
ENA Engineering Recommendation G98/1	Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019
ENA Engineering Recommendation G99/1	Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
IET Guidance Note 1	Selection and Erection
IET Guidance Note 3	Inspection and Testing

40.2 General

The Contractor and their Specialist Commissioning Engineers shall include for regular meetings with the Engineer during the course of the contract with a minimum of 4 (four) dedicated pre-commissioning meetings to review details of system commissioning provisions.

The contractor shall submit their method statement for testing, commissioning, and handover within one month of the contract award and shall regularly update thereafter to incorporate the Engineers comments and/or ongoing developments.

The Contractor shall carry out the testing, commissioning, proving and demonstration of all mechanical and associated electrical systems within the contract programme. The Contractor shall be fully responsible for providing management of all the above-mentioned activities and shall liaise with the Engineer. As a minimum requirement the Contractor shall provide the following scope of management functions.

- 1) Preparation of method statements for commissioning procedures of all systems
- 2) Review designs and drawings and advise on any measures that would assist the commissioning process
- 3) Review the interfaces of all packages and construction programmes to formulate a structured commissioning programme
- 4) Attend all necessary off site works testing
- 5) Produce standard documentation for the pre-commissioning/testing/ signing off of systems.
- 6) Manage the commissioning progress of each discipline individually and co-ordinate the interface of disciplines by carrying out the following duties:
 - Monitor progress to programme.
 - Attend and witness testing procedures with specialist
 - Agree test results for presentation to Engineer
 - Witness random tests as dictated by Engineer or Statutory Bodies
 - Advise statutory bodies of the availability of systems for their witnessing/inspection
 - Advise of required course of action where design parameters are not achieved
 - Sign off all systems to satisfaction of Engineer and Statutory Bodies. Issue copies of relevant record documents
 - Chair and minute all commissioning meetings
- 7) Produce and document a complete set of final commissioning and testing record documents
- 8) Arrange demonstrations of all systems to Employer's staff
- 9) Produce method statements and test scripts for the Integrated Systems Testing
- 10) Organise and manage the Integrated Systems Testing

- 11) Produce and document a complete set of final performance testing record documents
- 12) Monitor all plant functions during reliability proving period, and publish reliability

The Contractor shall include for liaison with the other contractors and key equipment suppliers, whom shall provide separate Test / Commissioning Engineers to attend site to carry out all of the commissioning. This shall include, but not be limited to, the following:

- BMS Contractor
- CRAC Works Contractor
- Chiller Works Contractor
- Pump Works Contractor
- AHU Works Contractor

The Contractor shall also liaise with the following parties and keep them informed of commissioning progress and opportunities to witness the systems:

- Site FM Team
- Client Project Team

During construction of the works the contractor shall undertake all necessary tests to ensure compliance with regulations and the specifications relating to the works.

Where any part of the installation is to be concealed within the building fabric tests shall be made to ensure that the installation is satisfactory prior to concealment.

The contractor shall keep a record of the results of each test on site. Such records shall include details of sections tested, remedial measures taken, sections of works replaced. This record is required to be signed off by the Engineer and the Client.

All labour, communication two-way radios and test instruments shall be provided by the Contractor for carrying out the tests. The instruments shall be correctly calibrated and certified for the limits of accuracy required and shall be operated by competent persons, trained in the use of the instruments. Calibration certificates for the instruments shall be attached to the test certificates. If in the Engineer's opinion a particular instrument is not suitable then an acceptable alternative shall be provided.

The Engineer shall be at liberty to demand the use of any testing instrument or apparatus that he may reasonably consider to be necessary in the execution of the testing.

In the event of the works being incomplete and causing a postponement of the notified verification of test date or the installation failing to pass the test the Employers Agent shall be at liberty to deduct from the contract price all expenses incurred by them and the Engineer, in attending the repetition of the tests.

Upon completion of the works the whole installation shall be subjected to the tests detailed within the relevant specification for the item of works and as detailed on the Engineers Inspection sheets. Every defect shall be noted, corrected and brought to the notice of the Employers Agent. Prior to final acceptance of the installation, all tests shall be repeated either in whole or in part and witnessed by the Engineer to their full satisfaction.

40.3 Introduction

The contractor shall carry out the testing and commissioning, which will enable the development to be put into full operation. This shall be read in conjunction with the following:

- Testing and Commissioning requirements of the Standard Specification for Mechanical Engineering Services
- Testing and Commissioning requirements of Specification of Fire Engineering Services

To achieve this, access to all factory acceptance tests must be available, and have been carried out for the following equipment:

- Transformers
- Generators
- UPS & Batteries
- High/Medium Voltage switchgear
- Main Low Voltage switchgear
- Power Distribution Output Switchboards
- Power Distribution Units & Static Switches
- Motor Control Centres

Site acceptance tests shall be carried out by the specialist installer/manufacturer in accordance with Red Engineering Design standard and particular specifications for all electrical systems including but not limited to the following equipment:

- Transformers
- Generators (including bulk fuel & air start systems)
- High/Medium Voltage switchgear
- Main Low Voltage switchgear
- UPS & Batteries
- Power Distribution Output Switchboard
- Power Distribution Units & Static Switches
- Motor Control Centres / BMS
- Fire Alarm System
- Fire Suppression Systems (Gas & Water) including pressure relief arrangements
- VESDA (pre alarm sensitive smoke detection system)
- Heat load tests/Integrated Building Tests
- Electrical & Fire cause and effect tests
- Security/CCTV/Access Control/Intercom functional tests
- Ambient & Emergency Lighting
- Power Monitoring
- Lightning Protection

The Contractor shall allow for all necessary test equipment, load banks and fuel to carry out the tests to the client's satisfaction.

The Contractor shall produce individual test sheets for each item of equipment.

40.4 Testing and Commissioning: Works Test

40.4.1 Manufacturers Tests

Test at works all items for which this is required by the appropriate European Standard, Country standard, by this Specification and otherwise as may be directed.

Where specified works tests shall be witnessed tested and inspected by the mechanical and electrical consultant or their representative at the factory. The Engineer shall be given 4 weeks' notice of any such works witness test.

The contractor shall allow for the provision of method statements, detailing the duration of the inspections and tests on each item of equipment for the approval of the Engineer 4 weeks in advance of the tests. The Engineer's comments shall be incorporated into such method statements.

Witness tests shall fully cover all tests and inspections identified within the specifications and items identified on the Engineers Works Inspection Sheet corresponding to the plant item.

The contractor shall include within this tender travelling and accommodation costs for 2No Engineers, plus the Employer and the Employer's Agent for the duration of the tests.

The contractor shall provide such assistance, labour, materials, electricity, fuel, stores, apparatus and instruments as may be requisite and as reasonably deemed necessary to carry out such tests efficiently.

All instruments used for the tests shall have a current calibration certificate available for inspection at works.

If the contractor fails to demonstrate the performance of the equipment offered he will be requested to carry out further tests until the Employer's Agent is fully satisfied that the equipment offered meets the requirements of the specification at no extra cost to this contract.

40.4.2 Inspection and Testing During Manufacture

The Engineer shall be entitled at all reasonable times during the manufacture to inspect, examine and test on the contractor's premises the materials and workmanship of all plant to be supplied under the contract and if part of the said plant is manufactured on other premises, the contractor shall obtain for the Employer's Agent's permission to inspect, examine and test as if the said plant were being manufactured on the contractor's premises. Such inspection, examination or testing, if made, shall not relieve the contractor from any obligation under the contract.

40.5 Testing and Commissioning: Site Tests and Commissioning

40.5.1 Documentation

The Engineer shall be issued with detailed method statements for each test at least 4 weeks prior to carrying out the works. The method statements shall detail the following:

- Health and safety issues
- Instruments to be used and their calibration certificates
- Sequence of tests to be carried out
- Documentation, which shall be provided to record results. This documentation shall be fully completed with all design information

In addition to the testing and commissioning method statements the contractor shall prepare an approved Commissioning File for each item or system including checklists which shall be used throughout the project to record all inspections, tests, test results, all certification, type test certificates, etc.

The Commissioning File be made available to the Engineer no later than 10 weeks before the Site Commissioning is due to commence and shall include testing and commissioning matrix showing status of the following:

- Client/design requirements
- Commissioning plan
- Test engineers competency documentation
- Tech Sub reviews and comments
- Test equipment calibration
- System coordination plans

- Inspection checklists
- Inspection reports
- Test Procedures, Method statements, etc.
- Test reports
- Field inspection issues and remedial actions
- Commissioning meeting agendas and minutes
- Commissioning plans and procedures
- Commissioning reports
- Sectional completions
- Certification
- Training plan
- Systems manuals

The Contractor shall keep this document up to date on site and make available for inspection by the Contract Administrator or the Engineer upon request.

Such records shall include details of sections tested, remedial measures required and taken, sections of works replaced, any and all repairs or changes made on site.

40.5.2 Sites tests

A visual inspection shall be made of the installed equipment before any tests are carried out to confirm the following:

- Correct selection of materials and compliance with specifications, drawings and/or equipment schedules.
- No damage has been caused during delivery, offloading, positioning and installation
- The workmanship associated with the installation meets the requirements of this specification
- The plant and equipment is installed in accordance with the project drawings and specifications
- **There are no signs of damage so as to impair safety**

This inspection shall be completed with the part of the installation under inspection disconnected from the electrical supply.

The Engineer shall be issued with detailed method statements for each test at least 4 weeks prior to carrying out the works. The method statements shall detail the following:

- Documentation, which will be provided to record results. This documentation shall be fully completed with all design information and is required to be signed off by the Engineer, and the Client.

40.5.3 Commissioning

Commissioning shall be carried out in a minimum of two stages. A pre-commissioning stage shall incorporate safety checks, acoustic measurements, etc. A full pre-commissioning report shall be prepared and issued to the Engineer. The report shall in addition to the test results, include proposals for any changes to plant to meet the operating characteristics of the systems as installed.

The contractor shall verify the correct operation of the whole electrical installation including items of plant to ensure that it is operating in accordance with the specified conditions and that the systems achieve the performance required.

This shall include proving of equipment installed under full load conditions. Where heat loads or electrical loads are not inherent in the installation temporary heat loads and electrical loads shall be provided.

Upon completion of all testing and commissioning, the contractor is to show that the equipment, materials and installations have been tested and commissioned shall provide two copies of the commissioning certificates. Each certificate shall be signed by the contractor and submitted to the Engineer within 14 days of the results being obtained. Signed copies of certificate shall be included within the operating maintenance manuals.

The whole of the commissioning and testing shall be carried out with the full knowledge of the Engineer. The Contractor shall give 14 working days' notice of all works tests which the Contractor is undertaking.

Any test carried out without the specific knowledge of the above parties shall be deemed null and void and repeated at the cost of the Contractor.

Engineering systems shall have been fully commissioned by the Contractor prior to final witnessing. It shall be the Contractor's responsibility to ensure that the Engineers time is not wasted by witnessing systems that have not been fully commissioned. The Contractor shall reimburse the Engineer all costs associated with witnessing systems on which the commissioning has not been completed.

Where failure during a test, inspection or commissioning process results in damage to the building fabric and/or any services, whether provided as part of this contract or not, then the remedial works shall be carried out at the Contractor's expense.

Documentation to show that systems have been commissioned shall be provided to the Engineer at the time he is notified of the proposed witness tests.

The whole of the Contract Work shall be left in a fully commissioned and tested state to the total satisfaction of the Engineer.

Relevant sections of the British Standards Specification, Guides and Codes of Practice shall be consulted and put into practice during the commissioning and testing programme.

Where specific requirements of the specification are described over and above those given in the guides, these shall also be adhered to.

The Contractor shall provide, at their own cost, unless stated to the contrary, all water, power, fuel, labour etc, necessary for all testing and commissioning of the plant.

40.5.4 Specialist Commissioning Firm

The Contractor may, if he so desires, employ the services of a specialist commissioning and testing firm.

The commissioning and testing works shall be carried out by competent personnel only.

Any firm that the Contractor proposes must be agreed with the Engineer prior to commencement of commissioning and testing.

40.6 Testing and Commissioning Plan

A testing and commissioning plan with all associated specific system method statements shall be submitted at least 12 weeks prior to commencement of the testing and commissioning and shall regularly update thereafter to incorporate the Engineers comments and/or ongoing developments.

The contractor shall provide the Engineer with full and detailed method statements for the pre-commissioning, setting to work, commissioning, testing and handover procedures to be applied to the whole of the works.

This procedure shall also be adhered to for works associated with operational systems/areas.

Where specialists are required to undertake the works, the contractor shall obtain similar documents from them and incorporate them into the Works Method Statement.

The following shall be included within the method statement for each system:

- a) Logic diagram of the process flow
- b) Outline programme, detailed programme(s) to be added as the document develops
- c) Copies of all check lists, record sheets, etc. proposed for use. Ensure all are clearly specific to the project and complete with design information and schematic drawings
- d) Isolation procedures
- e) Permit to work systems and documentation
- f) Details of works by others on which the contractor depends on being complete and at what time to maintain programme progress
- g) Proposed off site testing
- h) Proposed completion of work in zones
- i) Proposals for quality control of the work prior to offering to the Employer's Agent.
- j) Handover, demonstration and training

The Engineer reserves the right to request additional method statements from the contractor for any other aspect of the works, at their discretion at no additional cost.

40.6.1 Recording, Readings and Commissioning Report

A copy of all commissioning and testing documentation shall be issued to the Engineer at least four weeks prior to the commencement of the functional performance testing of each system.

The documentation shall include the following:

1. Commissioning test sheets with all design data filled in
2. Simple system schematics detailing the location of all test measurements

The commissioning test sheets shall typically include the following.

1. Project title
2. Details and date of test
3. Instruments used with serial numbers and calibration certificates
4. Contractors name
5. Signature of commissioning engineer
6. Signature of witnessing engineer

All measurements shall be fully recorded and submitted to the Engineer in the form of a Logbook to be agreed with the Engineer.

Finally, a full commissioning report shall be submitted to the Engineer on completion of the work.

40.7 Plant and Equipment Inspection, Testing and Commissioning

40.7.1 General

A competent engineer shall be employed to undertake the verification and testing of the electrical installation. As a minimum it is expected that this engineer will be conversant and proficient with the application of the current edition of BS 7671 or the equivalent national standard

40.7.2 High Voltage Installation

A High Voltage Inspection and Test Plan shall be agreed with the Engineer for the HV electrical installation.

The High Voltage Inspection and Test Plan shall provide for initial verification that the installation complies with BS EN 61936-1 and BS EN 50522, and also accommodate tests on-site for factory-built and type-tested equipment and factory assemblies in accordance with the relevant equipment standards and manufacturer's instructions. It will include for, but not be limited to:

- Verification of characteristics of the equipment (including rated values) for the given operating conditions
- Verification of minimum clearances between live parts and between live parts and earth
- power frequency voltage test for switchgear
- Voltage test for cables
- Verification of minimum heights and of protective barrier clearances
- Visual inspections and/or functional tests of electrical equipment and parts of installation
- Functional tests and/or measuring of protective, monitoring, measuring and controlling devices
- Inspection of markings, safety signs and safety devices
- Verification of correct fire ratings for buildings/enclosures
- Verification that emergency exits are operational
- Verification of the earthing system

Engineers conducting the initial verification of the high voltage installation will be conversant and proficient with the application of BS EN 61936-1, BS EN 50522, and attendant product standards.

40.7.3 Low Voltage installation

A competent engineer shall be employed to undertake the verification and testing of the electrical installation.

As a minimum it is expected that this engineer will be conversant and proficient with the application of the current edition of BS 7671 and the accompanying guides, with particular emphasis on Part 6 of BS 7671 and IET Guidance Notes 1 and 3.

Where staged commissioning, staged energisation of the installation, or a soft landings approach is utilized for the project, a Low Voltage Inspection and Test Plan shall be prepared which demonstrates how parts of the installation may be energized safely without adversely affecting safety on remaining works in progress, or future verification and commissioning tasks. The Low Voltage Inspection and Test Plan shall be approved by the Engineer.

40.7.4 Test instruments and test equipment for testing and commissioning

All labour and test instruments shall be provided for carrying out the tests.

Test instruments shall comply with appropriate standards, including but not limited to BS EN 61243-series, BS EN 61557-series, BS EN 61010-1 and BS EN 61010-031.

Instruments shall be correctly calibrated by a UKAS accredited test laboratory certified to BS EN ISO/IEC 17025, and certified for the limits of accuracy required. Test equipment and shall be operated by competent persons, trained in the use of instruments, in accordance with BS EN 50191.

Calibration certificates for the instruments shall be attached to the test certificates. If, in the Engineer's opinion, a particular instrument is not suitable then an acceptable alternative shall be provided.

The Engineer shall be at liberty to demand the use of any testing instrument or apparatus that he may reasonably consider to be necessary in the execution of the testing.

In the event of the works being incomplete and causing a postponement of the notified verification of test date or the installation failing to pass the test the Engineer shall be at liberty to deduct from the Contract Price all reasonable expenses incurred by him, in attending the repetition of the tests.

40.8 Transformer Tests

Carry out a visual inspection of all transformers to be worked on under the contract, prior to any work commencing

Existing transformers that are found to be leaking shall be immediately reported to the engineer, together with the oil level reading from the sight glass, where applicable.

Transformers shall be checked and inspected for mechanical damage and oil leaks upon arrival to site. Any damage or leaks found shall be remedied prior to installation. The oil level upon delivery to site shall be verified with the supplier.

Before measurement the transformer shall be at rest in a constant ambient temperature for at least four hours.

Insulation resistance tests shall be carried out between windings and all windings to earth and verified with the factory test results. The results shall be forwarded to the engineer.

The Contractor shall include for the manufacturer to retest the transformer on site prior to energisation. These tests shall be witnessed by the engineer or their representative as follows:

- Insulation resistance test
- MV to grounded LV > 20 M Ohms
- LV to grounded MV > 10 M Ohms
- LV to grounded frame > 20 M Ohms
- Measurement of winding resistance
- Measurement of the transformation ratio and vector group
- Measurement of impedance voltage and load loss
- Measurement of no load loss and no load current
- 5kV Megger test (HV to LV winding)

The tests shall be carried out using a 'megger' test instrument at 5kV for MV tests and 3kV for LV tests.

Ancillary devices and equipment such as oil sight glass, silica breather pots, protection relays, thermocouples/thermometers, fans etc. shall be fitted in accordance with the manufacturer's recommendations. Where a breather pipe is specified to be left open to the atmosphere ensure that the pipe is not restricting air flow prior to the transformer being energised.

40.9 Testing of HV Installations General

An Inspection and Testing Plan shall be agreed with the Engineer for the HV electrical installation.

The Test Plan shall provide for initial verification that the installation complies with BS EN 61936-1 and BS EN 50522, and also accommodate tests on-site for factory-built and type-tested equipment and factory

assemblies in accordance with the relevant equipment standards and manufacturer's instructions. It will include for, but not be limited to:

- Verification of characteristics of the equipment (including rated values) for the given operating conditions
- Verification of minimum clearances between live parts and between live parts and earth
- Power frequency voltage test for switchgear
- Voltage test for cables
- Verification of minimum heights and of protective barrier clearances
- Visual inspections and/or functional tests of electrical equipment and parts of installation
- Functional tests and/or measuring of protective, monitoring, measuring and controlling devices
- Inspection of markings, safety signs and safety devices
- Verification of correct fire ratings for buildings/enclosures
- Verification that emergency exits are operational
- Verification of the earthing system

40.10 Testing of HV Cables

Test all high voltage cabling installed subjected to works under the contract. Ensure that the person conducting the tests is competent and proficient in the area of medium voltage testing.

Provide all labour, apparatus and instrumentation necessary to fulfil the requirements of the medium voltage tests.

Inform the engineer one month in advance of any high voltage testing that is to be carried out on the installation.

A DC pressure test shall be applied to the medium voltage system that is associated with this contract. The tests shall be deemed successful when no breakdown is evident.

Where the cables cannot be readily isolated from the transformer or from an item an of switchgear then the Contractor shall determine the required voltage level and duration and confirm the data to both the Engineer and the test engineer two weeks in advance of any tests.

40.11 Switchgear

40.11.1 HV/MV Switchgear

Ensure that all tripping and closing batteries are fully charged.

In addition to the manufacturers commissioning and test procedures the sub-contractor shall also include for the following in their on-site testing of the HV switchboard.

- Busbar Tests
 - Torque tests on all bolted connections
 - Ductor tests
- Current transformers (CT)'s and Voltage transformers (VT's)
 - Phasing and ratio tests
 - Polarity
 - Magnetising curves
 - CT resistance and insulation
- Secondary Injection
 - Relays and settings
 - Meter calibration

- Intertripping
- Primary Injection
 - Functional checks and settings
 - Mechanical and Electrical interlocks
- Discrimination and application of final circuit protection settings relative to load conditions
- Operation of all switches and controls shall be demonstrated to the satisfaction of the Engineer
- Tripping at normal and reduced voltages, also other operational checks on all circuit breakers and associated secondary circuits
- Where required, tests shall be carried out on intertripping, indication and alarm circuits between medium voltage switchboards and high voltage switchboards in conjunction with the LV switchboard installer
- Interlock and intertrip sequence operation shall be carried out
- The sub-contractor shall allow in their quotation for making recommendations and setting-up of the time and current settings of all protection relays to provide satisfactory discrimination in each circuit
- Carry out a complete protection grading and setting calculation of the complete electrical distribution system, including all connected equipment
- Engage an independent Chartered Electrical Engineer to:
 - Undertake the calculation
 - Authenticate the calculations
 - Provide fault (short circuit) calculations for the distribution system as indicated on the drawings and a protective device co-ordination study to ensure that all protective devices are co-ordinated. Base the study on the actual devices and cable lengths installed.
 - Prepare the fault calculations and protective device study with a network analyzer, digital computer or by written calculations, include complete fault calculations for each proposed source and combinations thereof including motor and generator contributions.
- Present the fault calculations including the following:
 - General description of calculation methods, assumptions and base per unit quantities selected.
 - One line diagrams, source impedance data including X/R ratio and source system characteristics.
 - Impedance diagrams, typical calculations, tabulations of calculation quantities and results, conclusions and recommendations
 - Calculation of three phase symmetrical fault currents at each switchboard, motor control centre and distribution board
 - Calculation of earth fault currents including the associated zero sequence impedance diagram
 - Tabulations, which include fault impedance, X/R ratios, asymmetry factors, motor contributions, short circuit MVA and symmetrical and asymmetrical fault currents
- Carry out the protective device co-ordination study including the following:
 - Time-current co-ordination curves graphically indicating the proposed co-ordination for the system on log-log graph transparencies. Include on each sheet, a complete title and one line diagram identifying the specific portion of the system covered
 - A detailed description of each protective device identifying its type, function, manufacturer and time current characteristics and tabulation of recommended settings
 - Include on the curve sheets, system HV equipment relay characteristics, pertinent transformer, motor and generator characteristics including up to the largest outgoing LV circuit breaker/fuse for each distribution board. Indicate manufacturing tolerances clearly showing the final grading margin
- Submit the calculation as a bound report for approval by the engineer, as indicated
- Upon approval by the engineer submit copies of the approved report
- Carry out adjustments of the protection settings to conform with the requirements of the report

- Ensure that discrimination is achieved throughout the network and select protective devices and settings accordingly

The Contractor shall include for the manufacturer to re-test the works for the LV switchpanels, after assembly, on site for the Engineer to witness. The site testing shall incorporate the following:

- Meggar Test (150M ohms minimum)
- All bolt torques to required Standard
- Clean panel thoroughly
- Flash test (2500V for one minute)
- All relays proved (secondary injection testing)
- System operation to be fully simulated and proved
- All labels inspected
- General overview
- Carry out full thermograph test of all new busbars and connections

The site test shall be offered for final inspection to the Engineer only when all services and builderswork within the switchroom are 100% complete and this shall be one week prior to the energisation of the switchpanel.

On no account shall, the switchpanel be energised without the prior approval of the Engineer following the site tests being carried out to the Engineer's satisfaction.

Should, for any reason, the switchpanel fail the tests, the Engineer can request a re-test until he is satisfied. Should the switchpanel fail again, the Engineer can instruct the manufacturer to provide a new panel at no extra cost to the Contract.

The Contractor shall also be deemed responsible for providing a temporary supply to the switchpanels to enable commissioning to proceed.

The Contractor shall include for balancing the phases upon final commissioning, if necessary. This shall include disconnecting the existing and new circuits and re-arranging the phases for all circuits as required, including re-labelling, to the Engineer's satisfaction.

40.11.2 MV Switchgear Ring-Main Units (RMUs)- Testing Requirements

Manufacturer shall provide type test report to prove compliance with BS EN 62271-200.

It shall be possible to test the core or the sheath insulation of the network cables while the RMU remains energised at rated voltage. It shall be preferable to carry out the phase by phase testing through a built-in facility without necessity to have access to cable compartment. The maximum test voltage shall be less than 38 kV DC for 10 minutes.

Any cable test access facility which requires the use of an additional loose devise shall not be acceptable.

Type test certificates shall be supplied for the following:

- Impulse withstand test,
- Temperature-rise test,
- Short-time withstand current test,
- Mechanical operation test,
- Checking of degree of protection,
- Switch, circuit breaker, earthing switch making capacity.
- Switch, circuit breaker breaking capacity.
- Internal arc withstand

- Checking of partial discharge on complete unit

In addition, for switches, test reports on rated breaking and making capacity shall be supplied.

For earthing switches, test reports on making capacity, short-time withstand current and peak short-circuit current shall be supplied.

The routine tests carried out by the manufacturer shall be backed by test reports signed by the factory's quality control department. They shall include the following:

- Conformity with drawings and diagrams,
- Measurement of closing and opening speeds,
- Measurement of operating torque,
- Checking of filling pressure,
- Checking of gas-tightness,
- Checking of partial discharges on individual components,
- Dielectric testing and main circuit resistance measurement.

All of the major type tests shall have been certified at an independent authority with the tests carried outside the country of manufacture.

40.11.3 LV Switchboards

For LV Switchgear, ensure that all tripping and closing batteries are fully charged.

- a. A high voltage pressure test shall be carried out with all isolators closed and power fuses fitted but having all control circuits disconnected. The panels shall withstand for one minute a pressure of 2kV across the following points.
 - Phase to phase
 - Phase to neutral
 - Phase to earth
 - Neutral to earth
- b. An insulation resistant test shall be made immediately following the pressure test and using a 500V-testing instrument. This test shall be made with all isolators closed and power fuses fitted but having all electronic components, time switches, and control equipment likely to suffer damage under test, removed. An insulation resistance of not less than 20 megohms shall be obtained between each of the following points:
 - Phase to phase
 - Phase to neutral
 - Phase to earth
 - Neutral to earth
- c. Switchboards shall be erected and commissioned by the manufacturer. This commissioning shall include checking the tightness of all bolted connections. Evidence of this should be provided in the form of low resistance measurements.
- d. The function of all items of equipment controls and instrumentations shall be verified and provided to the satisfaction of the engineer on site and a full set of commissioning data provided.
- e. Carry out an infrared survey of each switchboard once connected to its load to detect possible heat spots
- f. Check and confirm correct polarity of all conductors in all circuits.
- g. Works tests on busbars shall be in accordance with the requirements for routine tests to relevant parts of BS EN 61439 shall be included.
- h. Works tests on air circuit-breakers in accordance with the requirements of BS EN 60947-2 for routine tests shall be included.
- i. Approval of tests and test certificate or any waiver of testing by the Engineer shall not reduce the obligation to supply the complete equipment in accordance with the requirements of the Specification, Schedules and Drawings.

- j. Whenever electrical contract works involve the site assembly of major switchgear component and/or alteration of existing switch panels, employ a suitably qualified testing Engineer to apply high voltage insulation tests as described earlier to the panel.

40.12 Generators

40.12.1 General

Carry out the tests scheduled within the design documents at the manufacturer's works in accordance with the relevant parts of BS ISO 8528 and BS 7698. Where detailed the tests shall be witnessed by the Supervising Officer.

Provide a documented ISO Standard Acceptance Test that details the test results together with any special tests as scheduled. As a minimum, simulation of cold mains failure start, load test and mains reinstatement operations, operational tests of control system and all interfaces will be required.

Carry out any scheduled tests when the generator is delivered to site and set into place with all generator system components and interfaces complete.

40.12.2 Checking & Verification

The Contractor shall undertake full physical inspection of the generator installation to verify the conditions of the installation. This inspection shall include the following systems and components:

- Compressed air/battery starting system
- Auto-source changeover panel
- LV Distribution switchboard
- Inlet ventilation fans and control panel
- Outlet ventilation fans and control panel
- Generator radiator fans and control panel
- Common control panel (PLC controller)
- Generator MV switchboard
- Sub-main control panel
- Sub-main MV switchboard
- Generator link boxes
- Neutral link panel
- Neutral earth resistor
- Field wiring and control panel
- Fuel oil system and control panel

The checking and verification works shall follow the format described below:

a) Visual Inspection

- To ensure all components are included within the panel
- No components are missing or damaged
- Check that the main frame is level in all directions, engine and generator shafts are in correct alignment and vibration-absorbing devices are properly installed and located
- Check that all radiators and engine block water drain points are free from sludge and other blockages
- Check water and sump oil levels and that the water jacket is in working order
- Check engine, bolts, main drive coupling, valve clearances, fuel pump settings, governor settings, pipeline connections, exhaust couplings, flexible pipework, etc

b) Check Tightness of Control Terminations

- To ensure no loose connections to field terminals.

c) Check all required terminals are complete

- Visually check all field cables connected to correct terminals, verified against Record schematic drawings and cable schedules.
- Check all outgoing connections on the generator and at the control panel. All lugs for principal connections to have clean and bright contact surfaces, a suitable abrasive material being used where necessary.
- Check access panels and doors for proper opening and closing and for the functioning of any interlocks fitted.

d) Check and remove all debris inside control panel.

- Visually check to ensure all installation debris is removed from control panels.
- Check particularly for swarf and cable off-cuts lying on components and bottom of panel.
- Remove any debris with brush or vacuum.
- Visually check all field cables connected to correct terminals, verified against Record schematic drawings and cable schedules.
- Check all outgoing connections on the generator and at the control panel. All lugs for principal connections to have clean and bright contact surfaces, a suitable abrasive material being used where necessary.
- Check access panels and doors for proper opening and closing and for the functioning of any interlocks fitted

e) Check the following wiring for continuity and correctly terminate

- Continuity check on all field cabling, tested with continuity tester or multimeter with continuity function
- Perform megger test on each core of field cabling.
- On all AC power cables perform earth loop impedance test with appropriate tester

f) Check tightness of main terminals

- Check tightness of main power terminals, normally a busbar bolted connection. Check tightness of each connection using a torque wrench

g) Check main earthing of control panel

- Visual inspection of earthing of the control panel, ensuring integrity of the earthing system

h) Panel-mounted Hardware, Testing & Settings

- Visual confirmation of correct settings on any monitoring or tripping delays.
- Secondary inject all relays to prove the function and setting of the relay.
- Performing a megger test on each motor.
- Each overload trip unit shall be set at the Full Load Current of the motor. Verified against the motor rating plate.
- All fuses and MCCB's shall be checked for correct rating against Record drawings and installed plant

i) Diesel Fuel

- Examine the containers in which the fuel and lubricating oils were delivered and check that the types and grades of oils are as recommended for the unit
- Provide sufficient fuel oil in the tank for a six-hour test run

40.12.3 Testing & Commissioning

The Contractor shall fully test and commission the installation at full load. The Contractor shall provide a suitably rated resistive load bank to enable all generators to be tested at full load. The testing and commissioning shall include the following systems and components.

- Auto-source changeover panel.
- LV Distribution switchboard.
- Inlet ventilation fans and control panel.
- Outlet ventilation fans and control panel
- Generator radiator fans and control panel
- Common control panel (PLC controller).
- Generator MV/LV switchboard
- Sub-main control panel
- Sub-main MV/LV switchboard
- Generator link boxes
- Neutral link panel
- Neutral earth resistor
- Field wiring and control panel
- Fuel oil system and control panel
- Compressed air starting system
- Neutral earth resistor
- Field wiring and control panel
- Fuel oil system and control panel
- Compressed air starting system
- Synchronisation equipment

The testing and commissioning works shall follow the format described below:

a) Check note power supply

- Verify power supply is available, within acceptable limits and recorded for commissioning records
- Check and note power supply phase rotation
- Verification of mains supply phase rotation to ensure correct rotation of fans and pumps.

b) Battery Charger Tests

- Recording voltages and currents, from panel mounted instruments.

c) System input and output checks

- This test is to ensure all devices controlled by the generator system are connected to the correct PLC input and output channel.
- Verified by Human Machine Interface (HMI) display and serial connected PC or field controller.

d) Communication Link Checks

- Ensure operation of communication links between common control panel and sub-main control panels.
- Verified by serial connected PC and communication card LED's.

e) Generator Start from generator control panel

- To ensure on initial manual generator start, fuel, ventilation and cooling systems operate correctly
- To ensure on generator stopping all systems shut-down correctly.
- With the set isolated from the mains supply and the selector switch in the "manual" position, start the engine and allow it to run up to normal speed. Check that during the time the engine starter motor is in operation, the mains battery charger is automatically switched off to avoid it being overloaded by the reduction in voltage across the battery if necessary
- Check instruments and gauges for normal operation and response and that the generator voltage is being maintained within prescribed limits, making fuel allowances for no load connections.
- Stop engine by turning selector switch to "Off" position and verify that generator contactor opens at between 95% and 85% of normal voltage. Re-check water and oil levels
- Turn selector switch to "auto" position, disconnect the sensing circuit supply and check that the set starts, the mains contact opens and that the generator contactor closes in correct order. Re-connect the sensing circuit to verify that the engine stops on the restoration of the main supply and that contactors operate correctly.
- Check the colour of the exhaust gas at various loads to confirm the correct running of engine
- Check that the various engine safeguards operate satisfactorily.
- Check the vibration absorbing devices for proper operation and that the performance of all flexible connections, both mechanical and electrical is satisfactory.
- Test software using a serial connected PC by monitoring PLC ladder logic.

f) Generator start from HMI

- To ensure on HMI start from the common control section generators start, fuel, ventilation and cooling systems operate correctly.
- To ensure on HMI stop all systems shut-down correctly.
- Test software using a serial connected PC by monitoring PC ladder logic

g) Synchronising and Load Sharing

- A synchronising and load sharing test to be carried out at no load, 50% and 100% load.
- This testing requires knowledge of the operation of governor, synchronisers and AVR's to match voltages, frequencies and phase angles. Also, the knowledge of a load sharer and AVR to ensure the equal sharing of kW and kVA load. The Contractor shall provide proof of their expertise in this field prior to operating the equipment
- Verify the phase angle and voltage matching.
- Check phase rotation.

h) Load Testing

- Run the complete installation at 100% capacity for an uninterrupted period of 4 hours.
- For prime rated sets run the complete installation at 110% overload capacity for an uninterrupted period of 1 hour.

The objective of the testing is to prove the system as described on the Cause & Effect Matrix and flow diagram.

All functional tests shall be carried out at full load.

When all tests are satisfactory and agreed the lubricating oil and water levels shall be checked the fuel oil tanks shall be replenished to their maximum levels for both the day and bulk storage tanks and the set left in normal operating order.

Confirm the noise level is within specification. This should be measured at 1m from the external façade of the Generator room.

40.13 UPS

Carry out the tests scheduled within the design documents at the manufacturer's works. Where detailed the Supervising Officer shall witness the tests.

As a minimum, simulation of mains failure, short circuit of the UPS output, simulation of inverter short circuit, changeover systems, operational tests of control system and all interfaces will be required.

Carry out the functional tests scheduled within the design documents on site with all UPS system components and interfaces complete.

The following inspections and test procedures shall be performed by factory-trained field service personnel during the UPS system start-up.

40.13.1 Visual Inspection

- Inspect equipment for signs of damage.
- Verify installation per drawings.
- Inspect cabinets for foreign objects.
- Verify neutral and earth conductors are properly sized and configured.
- Inspect electrolyte level in cells (flooded cells only).
- Inspect all cell cases.
- Inspect each cell for proper polarity.
- Verify all printed circuit boards are configured properly.

40.13.2 Mechanical Inspection

- Check all control wiring connections for tightness.
- Check all power wiring connections for tightness.
- Check all terminal screws, nuts, and/or spade lugs for tightness.

40.13.3 Electrical Inspection

- Check all fuses for continuity.
- Confirm input and bypass voltage and phase rotation is correct.
- Verify control transformer connections are correct for voltages being used.
- Assure connection and voltage of the battery string(s).

40.13.4 Unit Start-Up

- Energise control power.
- Perform control/logic checks and adjust to meet specification.
- Verify DC float and equalise voltage levels.
- Verify DC voltage clamp and overvoltage shutdown levels.
- Verify battery discharge, low battery warning and low battery shutdown levels.
- Verify fuse monitor alarms and system shutdown.
- Verify inverter voltages and regulation circuits.

- Verify inverter/bypass sync circuits and overlap time.
- Perform manual transfers and returns.
- Simulate utility outage.
- Verify proper recharge

40.14 Low Voltage Distribution

40.14.1 General

The electrical installations shall be tested in accordance with Part 6 of the current edition of BS 7671 and IET Guidance Note 3.

Prior to the tests being carried out ensure that all information necessary to verify the installation is available and at hand. A list of the information not available for verification purposes shall be made available from the verifying inspection engineer to the engineer two in advance of the tests.

It should be noted that electronic components might sustain serious damage as a result of certain accepted electrical installation test procedures. Conductors and other circuit components shall be tested prior to them being connected to electronic components. Electronic equipment shall be tested in accordance with the manufacturer's instructions.

The presence of electronic components shall be noted clearly on the circuit cards and in operating and maintenance manuals with an indication that testing procedures may result in damage.

During construction of the works undertake all necessary tests to ensure compliance with the current edition of BS 7671/A1 and the Specification upon completion of the works.

40.14.2 Visual Inspection

A visual inspection shall be made in accordance with Part 6 of the current edition of BS 7671 to verify that the installed equipment is:

- a) In compliance with the applicable British Standards and Part 5 of the current edition of BS 7671/A1.
- b) Correctly selected and erected in accordance with the current edition of BS 7671/A1.
- c) Not visibly damaged so as to impair safety.

This inspection shall normally be completed with the part of the installation under inspection disconnected from the supply.

The detailed inspection shall include as a minimum requirement items listed under Part 6 of the current edition of BS7671.

40.14.3 Testing and Commissioning

Tests shall be completed on all the following items where relevant and in same sequence as the items are noted.

Verify during commissioning the correct operation of the whole installation including equipment etc. and ensure that it is operating in accordance with the specified conditions.

This shall include proving equipment such as TV/FM systems, Security Alarm systems, Lightning Protection Installations, Control and Monitoring systems etc.

All motors shall be tested to ensure correct rotation.

Equipment fitted with batteries shall be protected to ensure that no damage is sustained by the battery, battery charger or any other component during discharge or recharge of the batteries when operating unattended.

In the event of any test failing to comply, that test and those proceeding, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

- a) Continuity of protective conductors.
- b) Continuity of ring final circuit conductors.
- c) Continuity of functional earthing and bonding conductors in accordance with BS 7671 and BS EN 50310, including dead earth (2 point) tests.
- d) Insulation resistance.
- e) Protection by SELV, PELV or by electrical separation
- f) Insulation of non-conducting floors and walls.
- g) Polarity
- h) Protection by automatic disconnection of supply including but not limited to:
 - Earth electrode resistance
 - Earth fault loop impedance
 - Prospective fault current
 - Operating times of RCDs used for automatic disconnection of supply
 - Tests according to manufacturer's instructions to verify that power electronic convertors used for automatic disconnection of supply operate according to Regulation 419.2 of BS 7671.
- i) Operating times of RCDs used for additional protection.
- j) Phase sequence.
- k) Functional tests.
- l) Verification of voltage drop by measurement where this is to be verified by test.

The installation, or relevant part thereof, shall not be energized, even for testing purposes, until the tests specified in a) to g) have been satisfactorily completed.

All the tests shall be carried out in accordance with the guidance notes on the Wiring Regulations published by the Institution of Engineering and Technology and shall be in accordance with the requirements of Part 6 of the current edition of BS 7671. When measured with all fuse links in place, all switches (including, if practicable, the main switch) closed and, except for TN-C systems, all poles or phases of the wiring electrically connected together, the insulation resistance to earth shall be no less than the minimum value stated by the current edition of BS 7671 for cabling systems and fixed equipment.

When measured between all the conductors connected to any one phase or pole of the supply and, in turn all conductors connected to each other phase or pole, the insulation resistance shall be not less than 1 megohm. Wherever practicable, so that all parts of the wiring may be tested, all lamps shall be removed and all current using equipment shall be disconnected and all local switches controlling lamps or other equipment shall be closed

Wherever practicable, so that all parts of the wiring may be tested, all lamps shall be removed and all current using equipment shall be disconnected and all local switches controlling lamps or other equipment shall be closed.

Where equipment is disconnected for the tests prescribed in Part 6 of the current edition of BS7671 and the equipment has exposed conductive parts required by the protective conductors, the insulation resistance between the exposed conductive parts and all live parts of the equipment shall be measured separately and shall comply with the requirements of the appropriate British Standard for the equipment. If there is no appropriate British Standard the insulation resistance shall be not less than the minimum value stated by the current edition of BS 7671 for cabling systems and fixed equipment. The test voltage may be reduced to 250

V DC in accordance with BS 7671, where electronic surge protection or similar devices would effectively operate during a 500 V test.

The phase sequence shall be tested and checked at all main distribution boards to ensure that it is correct. Unless detailed otherwise, the phase sequence shall be L1, L2, L3 (Brown, Black, Grey) in an anticlockwise direction.

40.14.4 Certification

Following the initial verification and testing required by Part 6 of the current edition of BS7671, a schedule of tests and Test Certificate shall be forwarded to the Engineer. The test schedule shall be a NICEIC document complete with unique reference number.

All circuits and equipment found defective shall be investigated, remedied and re-tested. A copy of this documentation shall also be forwarded to the engineer.

Upon successful test results a uniquely numbered NICEIC, or equivalent local contracting body, Completion Certificate shall be forwarded to the Engineer for signing where appropriate. The Contractor shall include the original signed certificate in the O&M manual. The Contractor shall also provide a copy of the relevant certificates with the drawings in each switch panel/distribution board. Any deviations from British Standard documents shall be agreed with the Engineer before the Completion and Inspection Certificate is issued.

The Completion and Inspection Certificate shall be signed by a competent person or persons stating that the installation has been designed (where applicable), constructed and inspected and tested in accordance with the current edition of BS 7671/A1 or the equivalent local national standard.

An instruction notice to the effect that the installation should be periodically inspected, shall be secured to the main switchgear. The notice shall read as follows.

IMPORTANT

This installation should be periodically inspected and tested and a report on its condition obtained, as prescribed in the IET Wiring Regulations BS 7671 Requirements for Electrical Installations.

Date of last inspection: -

Recommended date of next inspection: -

Where the works required under this contract are to be connected to, or affect an existing installation obtain copies of the existing O&M manuals and existing as fitted documents together with any periodic inspection records and subsequent completion certificates.

40.14.5 Manufacturer's Test Certificates and Declarations of Conformity

Manufacturer's certificates of test at the specified duties held at the manufacturers works shall be submitted for switchgear and transformers etc. No item of equipment shall be delivered to site before the Engineer has given their approval of the test certificate.

Where no test procedures are given, this test shall be carried out in accordance with the appropriate British Standard (current edition) and subject to the Engineer's approval.

Copies of declarations of conformity shall be provided for all products where these are required by relevant legislation.

40.15 Wall-mounted Charts

Provide wall mounted schematic drawings of circuit layouts showing identification and duties of equipment, numbers and locations, controls and circuits.

Location of mechanical and electrical plant and equipment items.

Location of main incoming HV Switchgear.

All items required under Statutory or other Regulations.

Emergency operating procedures and telephone numbers for emergency call out service application to any system or item of plant and equipment.

All schedules or schematic diagrams shall be submitted to the Engineer or their representative for comment prior to erection.

In all main switchrooms, riser cupboards, plantrooms, or sub-stations a notice shall be provided and fixed in a conspicuous place, which is to be agreed with the engineer giving First Aid instructions for the method of treating persons suffering from electrical shock.

40.16 Lightning Protection system

Test and commission the lightning protection system in accordance with relevant parts of BS EN 62305. All test results and the method adopted for testing electrodes shall be recorded and forwarded to the Engineer.

The Contractor shall be responsible for appointing the Specialist to carry out all tests as detailed below, in accordance with the requirements of BS EN 62305 and equivalent European Standards and recording the results for certification of the system.

- Earth resistance of each earth electrode.
- The continuity of all conductors, bonds and joints comprising the entire system.

Only those conductors forming part of the lightning protection system shall be included within the tests above. All other connections shall be disconnected and electrically isolated.

The Specialist appointed by the Contractor shall supply all equipment and test instrumentation necessary for the complete testing of the installation at each building or facility. The accuracy of all tests, calibration of test instructions etc. shall be demonstrated to the satisfaction of the Engineer or their representative.

The Engineer or their representative shall be given 14 (fourteen) days advance warning of tests on each facility in order that they might be witnessed.

40.17 Emergency Lighting- Testing and Commissioning

Fully test the complete lighting and emergency lighting installation in accordance with BS 7671, BS EN 1838, BS 5266-7 and BS 5266-1: including latest amendments and provide measured reading of all tests undertaken.

Carry out full testing and commissioning of the automatic emergency lighting testing and monitoring system.

Carry out on completion of the installation works, together with any specialist equipment supplier /manufacturer, the complete testing, commissioning, and demonstration of the system operation as detailed below:

Carry out adjustments and calibration of all automatic control devices and systems to provide optimum operation.

Make available a suitable operative, familiar with lighting controls, as may be required to assist in any specialist equipment supplier / manufacturer throughout the commissioning period.
Ensure that CAD record drawings of the lighting installation and associated controls are completed and available on site to specialist equipment supplier / manufacturers prior to commissioning commencement.

Prepare a schedule of tests to be applied to the system to demonstrate correct operation of the installation. The installer shall replace all failed lamps of the installed luminaires during the course of the contract works. Luminaires shall be thoroughly cleaned before installation and shall be in a new clean condition at handover. The permanent lighting installation shall not be used for temporary lighting purposes during the contract, unless prior written approval is given, by the Services Engineer.

40.17.1 Prior to Commissioning

A visual inspection of the whole installation covering equipment and cable where accessible, to verify: -

- a) Compliance with BS EN 1838, BS 5266-7 and BS 5266-1
- b) Compliance with all other applicable British Standards
- c) Correctly selected and erected in accordance with BS 7671
- d) Not visibly damaged so as to impair safety
- e) Correctly labelled and installed
- f) Free from defects

The electrical installation shall be inspected and tested in accordance with BS 7671 and as specified in other parts of this specification.

As specified under It should be noted that electronic components may sustain serious damage as a result of certain accepted electrical installation test procedures. Conductors and other circuit components shall be tested prior to them being connected to electronic components. Electronic equipment shall be tested in accordance with the manufacturer's instructions.

The items, where relevant, to be tested shall be those listed under Section 39.15 of this specification (Low Voltage testing) and shall be tested in the sequence indicated.

40.17.2 During Commissioning

The operation of all luminaires and emergency lighting luminaires accessories and items of equipment and a check for proper function.

Demonstrate the operation of each self-contained luminaire under simulated mains failure condition to prove the luminaire output for the specified time and that the battery is fully recharged within 24 hours

Demonstrate the operation of each central battery system supported luminaire under simulated mains failure condition to prove the luminaire output for the specified time and that the battery to be fully recharged within 24 hours.

Functional test of all light switches, emergency lighting test switches and control devices.

40.18 Fire Alarm System

Provide testing and certification of the complete fire alarm system in accordance with BS 5839-1.

All commissioning and test results shall be recorded and contained within the Operating and Maintenance Manuals.

All manufacturers' certificates of equipment design to an approved quality management system and CIE component selection shall be deemed to be a requirement.

A specialist from the equipment manufacturers company shall undertake all commissioning tests performed on the fire alarm system. The contractor shall appoint the specialist and allow for attendance on the specialist.

Demonstrate that master panel site specific data is stored on separate digital storage device

Demonstrate that high sensitivity air aspirating smoke detections (HSSD) systems are tested in accordance with BS 6266 Appendix A.

Both the installation and the commissioning activities shall be undertaken as a single continuous operation.

Upon completion of the installation activity, the contractor shall Test, Start-up, Commission and Hand-over the system to the Client.

The contractor shall make use of the following documents to record test results and details of commissioning tests:

- Cable Test Sheets
- Installation Check Report
- System Layout Drawing(s)
- System Schematic Diagram(s)

In addition, Point Description Sheets which are used to configure the text descriptions displayed at the controller shall be provided by the Contractor a minimum of 4 weeks prior to the date agreed for commencement of commissioning.

Test all functions of the system, including software, to ensure that it operates in accordance with the requirements of the design specification and relevant standards.

Undertake audibility tests during which the sounders are operated continuously over a period of two hours.

40.19 Power Monitoring (Revenue)

Arrange for the inspection and testing of all works and equipment associated with power monitoring (revenue) installations, to verify the system and equipment integrity and functionality. All testing and certification shall be in accordance with the manufacturer's recommendations and shall also be in accordance with any additional requirements of BS 7671 (or local national equivalent).

Visual inspections of all installed monitoring equipment, CTs, head-end equipment, cabling etc. shall be carried out as detailed elsewhere.

All equipment shall be fully calibrated and checked for accuracy against the parameters detailed in the Particular Specification.

40.20 Electric Vehicle Charging Equipment Installation

Test and commission electric vehicle charging equipment installations according to BS 7671 and the IET Code of Practice for Electric Vehicle Charging Equipment Installations.

Include with the Electrical Installation Certificate and the Operating and Maintenance Manual, copies of the checklist and risk assessment for each electric vehicle supply equipment (EVSE) location, from the relevant

Annex of the IET Code of Practice for Electric: Annex B (Dwelling Installations), Annex C (On-Street Installations), Annex D (Commercial and Industrial Installations), Annex E (Fuel Filling Station Installations).

40.21 Solar PV Systems

Test and commission Solar PV systems according to BS 7671, BS EN 62446-1 and the IET Code of Practice for Grid-Connected Solar PV Systems.

Conduct tests required by the DNO for systems falling under ENA Engineering Recommendations G99 and G100.

40.22 Electrical Energy Storage Systems (EESS)

Test and commission EESS according to BS 7671 and the IET Code of Practice for Electrical Energy Storage Systems.

Conduct tests required by the DNO for systems falling under ENA Engineering Recommendations G99 and G100.

40.23 Explosive Atmospheres and Fuel Filling Station Installations

For areas with explosive atmospheres, testing shall be conducted in accordance with the relevant parts of BS EN 60079.

In Fuel Filling Stations, electrical testing and commissioning shall comply with the APEA/EI publication Design, construction, modification, maintenance and decommissioning of filling stations (Blue Book)

40.24 Specialist Works

Arrange for the inspection and testing of all specialist works or equipment to verify the system and equipment integrity and functionality. Where necessary engage a specialist test engineer.

Include for all specialist attendances within the works in order to provide for safe and fully functional systems in accordance with any specified design parameters.

40.25 Testing MICC Cables

Refer MICC Cable section of this specification

41.0 Treatment - Electric Shock

41.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
HSR 25	The Electricity at Work Regulations 1989 Guidance on Regulations.

41.2 General

In all main switchrooms, riser cupboards, plant rooms, or sub-stations a notice shall be provided and fixed in a conspicuous place, which is to be agreed with the Engineer giving full instructions for the method of treating persons suffering from electrical shock, as described in clause 224 of the HSE publication HSR 25 The Electricity at Work Regulations 1989 Guidance on Regulations.

42.0 Schematic Diagram

42.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN 61082-1	Preparation of documents used in electrotechnology.
BS EN IEC/IEEE 82079-1	Explosive Preparation of information for use of products. Principles and general requirements

42.2 General

In all main switchrooms mount a framed copy of the system schematic diagram, prepared in accordance with BS EN 61082-1 and BS EN IEC/IEEE 82079-1, to facilitate safe switching by competent personnel.

43.0 Software

43.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS EN ISO 9001	Quality management systems. Requirements
BS EN ISO/IEC 27001	Information technology. Security techniques. Information security management systems. Requirements
BS ISO 10007	Quality management. Guidelines for configuration management
BS ISO/IEC 26514	Software and systems engineering. Requirements for designers and developers of user documentation
BS ISO/IEC/IEEE 12207	Systems and software engineering. Software life cycle processes
BS ISO/IEC/IEEE 15288	Systems and software engineering. System life cycle processes
BS ISO/IEC/IEEE 26513	Systems and software engineering. Requirements for testers and reviewers of information for users

43.2 General

Ensure that, as far as practicable, all software is commercially available off-the-shelf.

Ensure that any programmable configuration, customisation and bespoke software is developed, tested and commissioned using relevant processes and procedures complying with BS ISO/IEC 12207 or BS ISO/IEC/IEEE 15288, supported by a quality management system meeting the requirements of BS EN ISO 9001.

Obtain on behalf of the end users all appropriate licences, permissions, copyright wavers, rights of use etc. from the owners of the software rights. Ensure that the end user is properly registered with the software supplier for support and appropriate updating. Provide documentation for application software in accordance with BS ISO/IEC 26513 and BS ISO/IEC 26514.

Manage configuration of software settings, data and design, in accordance with an appropriate Configuration Management Plan (CMP), complying as necessary with BS EN ISO 9001, BS ISO 10007, BS ISO/IEC/IEEE 12207 and BS ISO/IEC/IEEE 15288. Provide final configuration details along with the operation and maintenance manual on hand-over.

Manage information security of systems, software and data during design, implementation and commissioning in line with BS EN ISO/IEC 27001.

44.0 Construction Products Regulations (CPR) Requirements for Cables

44.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6701	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance. Specification for installation, operation and maintenance
BS 7671	Requirements for electrical installations
BS EN 13501-6	Fire classification of construction products and building elements. Classification using data from reaction to fire tests on power, control and communication cables
BS EN 50525	Power, control and communication cables. Cables for general applications in construction works subject to reaction to fire requirements.
BS EN 50575	Power, Control and communication cables. Cables for general applications in construction works subject to reaction to fire requirements
BS EN 60332-1-2	Tests on electric and optical fibre cables under fire conditions. Test for vertical flame propagation for a single insulated wire or cable. Procedure for 1 kW pre-mixed flame
BS EN 60332-3-series / BS EN IEC 60332-3-series	Tests on electric and optical fibre cables under fire conditions. Test for vertical flame spread of vertically-mounted bunched wires or cables.
BS EN 61034-2	Measurement of smoke density of cables burning under defined conditions. Test procedure and requirements

44.2 Minimum requirements for fire performance of cables

All cables shall be certified in accordance with the Construction Products Regulation (CPR) as required by BS 7671, BS 6701 and BS EN 50575. Unless a higher rating is otherwise specified:

- Cables to be installed where the risk of flame propagation is high (for example, cables that are bunched or are used in long vertical runs), or in a fire propagating structure, or run in a fire segregated compartment, shall meet at least either BS EN 60332-1-2 plus the relevant part of the BS EN 600332-3 series and BS EN IEC 60332-3 series, or BS EN 13501-6 EuroClass Dca.
- Cables encroaching on or run in escape routes shall meet at least either BS EN 13501-6 EuroClass Dca-s2, or the relevant part of BS EN 600332-3 series and BS EN IEC 60332-3 series plus achieve at least 60 % light transmittance when tested to BS EN 61034-2.
- Ensure all ICT cables that are intended for installation into pathways that are hidden below floors, behind walls, or to which access is limited, meet as a minimum BS EN 13501-6 EuroClass Cca-s1b,d2,a2.
- All other cables shall meet at least either BS EN 60332-1-2 or BS EN 13501-6 EuroClass Eca.

45.0 Renewable Power Systems

45.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
	IET Code of Practice for Electrical Energy Storage Systems
	IET Code of Practice for Grid-Connected Solar PV Systems
BS 7671	Requirements for electrical installations
BS EN 1991	Actions on structures.
BS EN 50549-1	Requirements for generating plants to be connected in parallel with distribution networks. Connection to a LV distribution network. Generating plants up to and including Type B
BS EN 50583-1	Photovoltaics in buildings. BIPV modules
BS EN 50583-2	Photovoltaics in buildings. BIPV systems
BS EN 60529	Degrees of protection provided by enclosures
BS EN 61194	Characteristic parameters of stand-alone photovoltaic (PV) systems.
BS EN 61215-series	Terrestrial photovoltaic (PV) modules
BS EN 61427	Secondary cells and batteries for renewable energy storage. General requirements and methods of test. Photovoltaic off-grid application
BS EN 61429	Marking of secondary cells and batteries with the international recycling symbol ISO 7000-1135 and indications regarding directives 93/86/EEC and 91/157/EEC
BS EN 61829	Photovoltaic (PV) array. On-site measurement of current-voltage characteristics.
BS EN 61853-series / BS EN IEC 61853-series	Photovoltaic (PV) module performance testing and energy rating.
BS EN 62109-1	Safety of power converters for use in photovoltaic power systems. General requirements
BS EN 62109-2	Safety of power converters for use in photovoltaic power systems. Particular requirements for inverters
BS EN 62116	Utility-interconnected photovoltaic inverters. Test procedure of islanding prevention measures
BS EN 62124	Photovoltaic (PV) stand-alone systems. Design verification.
BS EN 62281	Safety of primary and secondary lithium cells and batteries during transport
BS EN 62305	Protection against lightning. Risk Management
BS EN 62446-1	Photovoltaic (PV) systems. Requirements for testing, documentation and maintenance. Grid connected systems. Documentation, commissioning tests and inspection
BS EN 62477-1	Safety requirements for power electronic converter systems and equipment. General

STANDARD	TITLE
BS EN 62509	Battery charge controllers for photovoltaic systems. Performance and functioning.
BS EN 62909-1	Bi-directional grid connected power converters. General requirements
BS EN 62909-2	Bi-directional grid-connected power converters. Interface of GPC and distributed energy resources
BS EN IEC 61730-1	Photovoltaic (PV) module safety qualification. Requirements for construction
BS EN IEC 61730-2	Photovoltaic (PV) module safety qualification. Requirements for testing
BS EN IEC 62485-1 , BS EN IEC 62485-2	Safety requirements for secondary batteries and battery installations.
BS EN IEC 62933-series	Electrical energy storage (EES) systems.
BS HD 60364-8-1	Low-voltage electrical installations. Functional aspects. Energy efficiency
BS HD 60364-8-2	Low-voltage electrical installations. Prosumer's low-voltage electrical installations
BS IEC 62548	Photovoltaic (PV) stand-alone systems. Design verification.
ENA Engineering Recommendation G100/1	Technical requirements for customer export limiting schemes
ENA Engineering Recommendation G5/5	Planning Levels for Harmonic Voltage Distortion and the Connection of Non-Linear Equipment to Transmission Systems and Distribution Networks in the United Kingdom
ENA Engineering Recommendation G98/1	Requirements for the connection of Fully Type Tested Micro-generators (up to and including 16 A per phase) in parallel with public Low Voltage Distribution Networks on or after 27 April 2019
ENA Engineering Recommendation G99/1	Requirements for the connection of generation equipment in parallel with public distribution networks on or after 27 April 2019
PD IEC/TS 62446-3	Photovoltaic (PV) systems. Requirements for testing, documentation and maintenance. Photovoltaic modules and plants. Outdoor infrared thermography

45.2 General

All equipment enclosures to be mounted outdoors shall be protected to at least IP55 according to BS EN 60529.

Transformers, switchgear, protection and metering equipment shall comply with other respective parts of this specification and be sufficient to meet the system objectives.

Renewable power systems shall comply, as appropriate, with ENA Engineering Recommendations G98 or G99. If the system is to be used for export limiting or load curtailment, the principles of ENA Engineering Recommendation G100 shall be met.

The Contractor shall be responsible for DNO notification procedures, and, where required, arranging for testing and approval by the relevant DNO.

The renewable power systems will, as stated in the particular specification, be provided as an integrated system along with the overall energy management system (EMS).

45.3 Solar Photovoltaic (PV) systems

The objectives and rating of the Solar PV system relating to the installation are set out in the Particular Specification.

Engage a specialist to design, supply, install, commission and set to work the Solar PV System in accordance with BS EN 62124, BS 7671, the IET Code of Practice for Grid-Connected Solar PV systems, and the relevant ENA Engineering Recommendations. Solar PV systems with integral storage batteries shall also comply with the requirements for electrical energy storage systems (EESS).

Carry out acceptance tests and provide Acceptance Test Report in accordance with BS 7671, BS EN 62446-1, PD IEC/TS 62446-3, and any other specified requirements (e.g. IET Code of Practice for Grid Connected Solar Photovoltaic Systems). Conduct on-site measurement of PV array current-voltage characteristics in accordance with BS EN 61829.

Provide completely documented standard functional test report for the solar PV system in accordance with BS EN 62446-1.

Provide overview diagrams showing the distribution system of the normal power supply and power supply for safety devices in single line representation. in the operation and maintenance manual in accordance with BS 7671 and BS EN 62446-1.

45.4 Electrical energy storage systems (EESS)

The objectives and size of the EESS relating to the installation are set out in the Particular Specification.

Engage a specialist to design, supply, install, commission and set to work the EESS in accordance with BS 7671, the IET Code of Practice for Electrical Energy Storage Systems, and relevant ENA Engineering Recommendations. The specialist shall undertake a risk assessment for the system, and where appropriate, a DC arc flash hazard assessment.

The EESS shall comprise a storage battery, power converting equipment, battery management system, along with associated switchgear, protective devices and means of control.

Carry out acceptance tests and provide Acceptance Test Report in accordance with BS 7671, the IET Code of Practice for Electrical Energy Storage Systems, and any requirements of the distribution network operator according to ENA Engineering Recommendations G99 and G100.

Provide overview diagrams showing the distribution system of the normal power supply and power supply for safety devices in single line representation. in the operation and maintenance manual in accordance with BS 7671.

45.5 Power converting equipment

Inverters and power converting equipment shall comply as appropriate with BS EN 50549-1 BS EN 62109-1, BS EN 62109-2, BS EN 62116, BS EN 62509 and BS EN 62477-1.

45.6 Batteries and battery management

Low and extra-low voltage battery installations shall comply with BS 7671 and BS EN IEC 62485-1 and BS EN 62485-2.

The battery management system shall ensure charge and discharge of the batteries is conducted in line with the battery manufacturer's recommendations.

Batteries shall be labelled, transported, stored and installed in accordance with the battery manufacturer's instructions, and relevant legislation and BS EN 61429, and, where appropriate, BS EN 62281 for the safety of lithium cells during transportation.

The battery management system will interface with the building control and monitoring system and/or energy management system, and provide at least the following information in addition to that required by the Particular Specification:

- Battery health
- Battery fault
- System fault / tripped

Suitable means of isolation, appropriately identified in accordance with BS 7671, shall be provided to facilitate safe maintenance of the batteries.

Batteries shall be installed with adequate space taking into account the weight of batteries, and maintenance replacement procedures involved.

An emergency stop button shall be provided in the battery room or on the battery enclosure, which removes all charging input, and isolates the battery output.

45.7 Solar PV arrays

Provide photovoltaic modules and panels in accordance, as appropriate, with BS EN 61194, relevant parts of BS EN 61853 / BS EN IEC 61853, BS EN 50583, BS EN IEC 61730, and BS EN 61215.

Building integrated solar PV (BIPV) modules shall comply with relevant parts of BS EN 50583.

The method of mounting shall take account of anticipated wind speed, determined by the Contractor according to BRE Digest 489, and BS EN 1991.

Metal mounting frames shall meet the manufacturer's recommendations for the panels, be suitable for the windspeed, and mounting arrangements, and be bonded to the lightning protection system in accordance with the relevant parts of BS EN 62305.

Connect and cable solar PV arrays to the inverter or converter system in accordance with BS 7671, BS EN 62124 and the IET Code of Practice for Grid Connected Solar PV Systems.

45.8 Microgeneration Certification Scheme (MCS)

The PV system shall be compliant with MCS standards.

The technology used for the PV system shall be MCS accredited using MCS certified products.

The installation of the PV system shall be undertaken by an MCS approved contractor/ certified installer.

46.0 Electric Vehicle Charging Equipment

46.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
	IET Code of Practice for Electric Vehicle Charging Equipment Installation
APEA / EI 'Blue Book'	Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4 th Edition.
BS 7671	Requirements for electrical installations
BS 8300-1	Design of an accessible and inclusive built environment. External environment. Code of practice
BS 8300-2	Design of an accessible and inclusive built environment. Buildings. Code of practice
BS EN 60038	CENELEC standard voltages
BS EN 60255	Measuring relays and protection equipment. Functional requirements for distance protection
BS EN 61851-1	Electric vehicle conductive charging system. General requirements
BS EN 61851-21-1	Electric vehicle conductive charging system. Electric vehicle on-board charger EMC requirements for conductive connection to an AC/DC supply
BS EN 61851-22	Electric vehicle conductive charging system. A.C. electric vehicle charging station
BS EN 61851-23	Electric vehicle conductive charging system. DC electric vehicle charging station
BS EN 61851-24	Electric vehicle conductive charging system. Digital communication between a d.c. EV charging station and an electric vehicle for control of d.c. charging
BS EN 61936-1-series	Plugs, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles.
BS EN 62196	Plug, socket-outlets, vehicle connectors and vehicle inlets. Conductive charging of electric vehicles. Dimensional compatibility and interchangeability requirements for a.c. pin and contact-tube accessories
BS EN 62262	Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code).
ENA Engineering Recommendation G12/4	Requirements for the Application of Protective Multiple Earthing to Low Voltage Networks.

46.2 General

Electric vehicle (EV) charging equipment shall be installed as indicated on the relevant drawings and schedules. In the following sections, electric vehicle charging equipment is referred to as EVSE (electric vehicle supply equipment), in line with the relevant standards.

Where vehicle to grid (V2G) systems are specified, these shall additionally meet the requirements for electrical energy storage systems (EESS).

Engage a specialist EV charging equipment installer to design, install and commission the EV charging equipment in accordance with BS 7671, the IET Code of Practice for Electric Vehicle Charging Equipment Installation, and the EVSE manufacturer's requirements.

Where stated, the system shall be integrated with the energy management system (EMS), for the purposes, where appropriate, of:

- Load curtailment
- Energy metering and monitoring
- Billing
- Remote monitoring and resetting of protective devices

The means of connectivity for integration (wireless network, mobile network, wired network, industrial control and communications protocols) is indicated in the Particular Specification.

46.3 EV supply equipment (EVSE)

The EVSE shall be suitable for an input voltage of 230 V single-phase or 400 V 3-phase, 50 Hz, in accordance with BS EN 60038, as indicated in the drawings and schedules.

Mode 3 (AC) EVSE shall comply with BS EN 61851-1, BS EN 61851-21-1, and BS EN 61851-22.

Mode 4 (DC rapid charging) EVSE shall comply with BS EN 61851-1, BS EN 61851-21-1, BS EN 61851-23 and BS EN 61851-24.

EVSE shall support the following functions in accordance with BS 7671 and the relevant parts of BS EN 61851:

- Load curtailment (demand management)
- Pilot functionality
- DC residual current protection, either in-built, or installed alongside the EVSE, via either:
 - Type B RCCB or
 - Type A or Type F RCCB in conjunction with RDC-DD.
- Controls and indications complying with the accessibility requirements of BS 8300-1 and BS 8300-2 when installed.

Vehicle connectors shall comply with relevant parts of BS EN 62196.

Unless otherwise stated:

- Mode 3 EVSE shall be rated for 7.4 kW, 32 A single-phase charging and fitted as a minimum with a Type 2 connector.
- Mode 4 EVSE fitted as a minimum with a CCS2 (combined charging system) connector for 43 kW DC rapid charging at the maximum current rating stated.
- Combined Mode 3 / Mode 4 charging equipment will have one of each of the connectors described above, with the respective ratings.

46.4 Installation of EVSE

EVSE shall be installed in accordance with BS 7671, the IET Code of Practice for Electric Vehicle Charging Equipment Installation, and the EVSE manufacturer's requirements. Comply also with ENA Engineering Recommendation G12/4 and distribution network operator or lighting service operator requirements for electric vehicle charging equipment installation in on-street locations.

Where equipment is not mounted on the side of buildings, buried cables shall be used, installed as detailed in other parts of this specification.

Where EVSE has a different earthing system to surrounding adjacent buildings and outdoor equipment/street furniture, conduct the appropriate pre-installation check and risk assessment as detailed in the Annexes to IET Code of Practice for EV Charging Equipment Installation, prior to installation of each EVSE. Resolve any conflicts to the satisfaction of the Engineer.

Each vehicle connector outlet shall be supplied by its own final circuit protected by a suitable overcurrent protective device. Where EVSE contains a single vehicle connector, it shall be supplied by its own final circuit, protected by a suitable overcurrent protective device.

Where EVSE is to be connected to a PME earthing terminal, one of the following measures shall be satisfied, to the approval of the Engineer:

- a) EVSE is connected to a fully balanced three-phase system according to Regulation 722.411.4.1 (i) of BS 7671.
- b) The installation has an earth electrode or earth electrode system complying with Regulation 722.411.4.1 (ii) of BS 7671.
- c) The EVSE is protected by a device which detects open-circuit PEN conditions, suitable for three-phase systems, in accordance with Regulation 722.411.4.1 (iii) or (v). Such devices will:
 - comply with the requirements of BS 7671.
 - have a means of detection complying with relevant parts of BS EN 60255.
 - contain a means of disconnection for all line conductors, neutral, and protective conductor that is classed as a means of isolation in accordance with Table 537.4 of BS 7671.

All other protective devices shall comply with other relevant parts of this specification and be selected in accordance with BS 7671 and the IET Code of Practice for EV Charging Equipment Installation.

All EVSE shall be protected against mechanical damage classed as high severity (AG3 in BS 7671), by one of the following means:

- EVSE shall comply with a degree of mechanical protection against impact of IK08 in accordance with BS EN 62262
- EVSE shall be protected by impact barriers, arranged to maintain accessibility to the charging equipment and controls in accordance with BS 8000-1 and BS 8000-2
- Only where specifically approved by the Engineer, where the EVSE is installed in a position where there is no reasonably foreseeable risk of impact.

When installed, the entirety of socket-outlets, vehicle connectors, controls and simple indications shall be located between 0.75 m and 1.20 m above finished floor level used to access them, and the top of electronic displays shall be between 1.20 and 1.40 m above finished floor level used to access them.

Tariff meters shall be installed where billing is based on energy usage.

For installations within the curtilage of a filling station, comply with the requirements of the APEA / EI 'Blue Book' Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4th Edition. In particular:

- EVSE shall not be installed in the hazardous area
- EVSE shall only have tethered vehicle connecting cables.
- EVSE and respective parking spaces shall be located so that it is not possible to charge a vehicle in the hazardous area from the EVSE.
- EVSE shall contain an interface so that it is inoperable when the filling station is not in operation.

46.5 Testing and commissioning of EVSE installations

EVSE installations shall be inspected and tested in accordance with BS 7671 and the IET Code of Practice for EV Charging Equipment Installation.

Copies of the completed respective checklist from the Annexes of the IET Code of Practice for EV Charging Equipment Installation, for each EVSE, shall be included with the electrical installation certificate, and the operation and maintenance manuals.

Commissioning of the system shall include all functional checks recommended by the equipment manufacturers, including integration testing with the energy management system (EMS) and other required systems.

For installations within the curtilage of a filling station, comply with the testing and commissioning requirements of the APEA / EI 'Blue Book' Design, Construction, Modification Maintenance and Decommissioning of Petrol Filling Stations, 4th Edition.

47.0 ICT Cables

47.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 6701	Telecommunications equipment and telecommunications cabling. Specification for installation, operation and maintenance. Specification for installation, operation and maintenance
BS 7671	Requirements for electrical installations
BS EN 13501-6	Fire classification of construction products and building elements.
BS EN 50090-9-1	Home and building electronic systems (HBES). Installation requirements. Generic cabling for HBES class 1 twisted pair
BS EN 50173-1	Information technology. Generic cabling systems. General requirements
BS EN 50173-2	Information technology. Generic cabling systems. Office spaces
BS EN 50173-3	Generic cabling systems. Industrial spaces
BS EN 50173-4	Information technology. Generic cabling systems. Homes
BS EN 50173-5	Information technology. Generic cabling systems. Data centre spaces
BS EN 50173-6	Information technology. Generic cabling systems. Distributed building services
BS EN 50174-1	Information technology. Cabling installation. Installation specification and quality assurance
BS EN 50174-2	Information technology. Cabling installation. Installation planning and practices inside buildings
BS EN 50174-3	Information technology. Cabling installation. Installation planning and practices outside buildings Published Date: 31/10/2013 Status: Current
BS EN 50288-11-1	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for un-screened cables characterised up to 500 MHz. Horizontal and building backbone cables
BS EN 50288-11-2	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for un-screened cables, characterized from 1 MHz up to 500 MHz for work area, patch cord and data centre applications
BS EN 50288-3-1	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for unshielded cables characterised up to 100 MHz. Horizontal and building backbone cables
BS EN 50288-3-2	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for

STANDARD	TITLE
	unscreened cables characterised up to 100 MHz. Work area and patch cord cables
BS EN 50288-6-1	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for unscreened cables characterised up to 250 MHz. Horizontal and building backbone cables
BS EN 50288-6-2	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for unscreened cables characterised up to 250 MHz. Work area and patch cord cables
BS EN 50288-9-1	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for screened cables characterised up to 1 000 MHz. Horizontal and building backbone cables
BS EN 50288-9-2	Multi-element metallic cables used in analogue and digital communication and control. Sectional specification for screened cables characterized from 1 MHz up to 1 000 MHz for work area, patch cord and data centre applications
BS EN 60332-1-2	Tests on electric and optical fibre cables under fire conditions.
BS EN 60794-2-20	Optical fibre cables. Indoor cables. Family specification for multi-fibre optical cables
BS EN 60794-2-21	Optical fibre cables. Indoor cables. Detailed specification for multi-fibre optical distribution cables for use in premises cabling
BS EN 60794-2-40	Optical fibre cables. Indoor optical fibre cables. Family specification for A4 fibre cables
BS EN 60794-2-41	Optical fibre cables. Indoor cables. Product specification for simplex and duplex buffered A4 fibres
BS EN 60794-2-42	Optical fibre cables. Indoor optical fibre cables. Product specification for simplex and duplex cables with A4 fibres
BS EN 60794-3	Optical fibre cables. Sectional specification. Outdoor cables
BS EN 60794-30	Optical fibre cables. Indoor cables. Family specification for optical fibre ribbon cables for use in terminated cable assemblies
BS EN 60794-3-10	Optical fibre cables. Outdoor cables. Family specification for duct, directly buried or lashed aerial optical telecommunication cables
BS EN 60794-3-12	Optical fibre cables. Outdoor cables. Detailed specification for duct and directly buried optical telecommunication cables for use in premises cabling
PD CLC/TR 50174-99-1	Information technology. Cabling installation. Remote powering
PD CLC/TR 50174-99-2	Information technology. Cabling installation. Mitigation and protection from electrical interference

47.2 General

ICT cable planning and design shall be in accordance with BS EN 50173-series, BS 6701, BS 7671 and BS EN 50174-series.

Unless otherwise specified, ICT cables shall be low smoke, zero halogen (LS0H or LSZH).

47.3 Fire Performance of ICT Cables

Fixed data installation cables shall meet at least BS EN 13501-6 EuroClass C_{ca}-s1b, d₂, a₂, or higher rating as indicated on the relevant cable schedule. Patch cords shall meet at least BS EN 13501-6 EuroClass E_{ca} or the requirements of BS EN 60332-1-2.

47.4 Installation of ICT Cables

Install ICT cables in accordance with BS 7671, BS 6701 and the relevant parts of BS EN 50174.

Use methods of installation, fixing and restraint that do not deform the cross-section of cables in a manner that might otherwise affect the data / signal performance of the cable. Cable protection mats shall be used in baskets in which unarmoured copper data cabling is installed.

All ICT cables shall be supported against premature collapse in the event of fire, in accordance with Regulation 521.10.202 of BS 7671. Under no circumstances shall cables be fixed to the underside of cable trays, trunking or cable basket.

No ICT cables shall be laid directly on the ground or floor. Appropriate cable containment shall be used.

47.5 ICT Cable termination

ICT Cables shall be terminated in accordance with manufacturer's instructions, and in accordance with the schedule drawings.

47.6 Testing of ICT Cables

All ICT fixed wiring cables shall be tested after installation and before being put into service to ensure that they are serviceable and meet the required standards for data rate. As part of these tests:

- all copper fixed wiring ICT cables shall be subjected to a time division reflectometry (TDR) test to ensure there are no deformities or damage
- all optical fibre cables shall undergo agreed transmission tests

The Engineer reserves the right to witness any tests.

48.0 Supplies for Safety Services

48.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
BS 5266-1	Emergency lighting. Code of practice for the emergency lighting of premises
BS 5499-4	Safety signs. Code of practice for escape route signing
BS 5839-1	Fire detection and fire alarm systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises
BS 5839-3	Fire detection and alarm systems for buildings. Specification for automatic release mechanisms for certain fire protection equipment
BS 5839-6	Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of fire detection and fire alarm systems in domestic premises
BS 5839-8	Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of voice alarm systems
BS 5839-9	Fire detection and fire alarm systems for buildings. Code of practice for the design, installation, commissioning and maintenance of emergency voice communication systems
BS 7671	Requirements for electrical installations
BS 7698-12	Reciprocating internal combustion engine driven alternating current generating sets. Emergency power supply to safety devices
BS 8434-2	Methods of test for assessment of the fire integrity of electric cables. Test for unprotected small cables for use in emergency circuits. BS EN 50200 with a 930° flame and with water spray
BS 8491	Method for assessment of fire integrity of large diameter power cables for use as components for smoke and heat control systems and certain other active fire safety systems.
BS 8519	Selection and installation of fire-resistant power and control cable systems for life safety, fire-fighting and other critical applications.
BS EN 1838	Lighting applications. Emergency lighting
BS EN 1838	Lighting applications. Emergency lighting.
BS EN 50171	Central power supply systems.
BS EN 50200	Method of test for resistance to fire of unprotected small cables for use in emergency circuits.
BS EN 60073	Basic and safety principles for man-machine interface, marking and identification. Coding principles for indicators and actuators.

STANDARD	TITLE
BS EN 60332-1-2	Tests on electric and optical fibre cables under fire conditions. Test for vertical flame propagation for a single insulated wire or cable. Procedure for 1 kW pre-mixed flame
BS EN 60623	Secondary cells and batteries containing alkaline or other non-acid electrolytes. Vented nickel-cadmium prismatic rechargeable single cells.
BS EN 60702-1	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Cables
BS EN 60702-2	Mineral insulated cables and their terminations with a rated voltage not exceeding 750 V. Terminations
BS EN 60896-11	Stationary lead-acid batteries. General requirements and methods of test. Vented types. General requirements and methods of tests
BS EN 60896-21	Stationary lead-acid batteries. Valve regulated types. Methods of test
BS EN 60896-22	Stationary lead-acid batteries. Valve regulated types. Requirements
BS EN 62040-3	Uninterruptible power systems (UPS). Method of specifying the performance and test requirements
BS EN 62040-5	Uninterruptible power systems (UPS) - DC output UPS. Performance and test requirements
BS EN 62040-4	Uninterruptible power systems (UPS) - DC output UPS. Performance and test requirements
BS EN IEC 60331-1	Tests for electric cables under fire conditions. Circuit integrity. Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter exceeding 20 mm
BS EN IEC 62040-1	Uninterruptible power systems (UPS). Safety requirements
BS EN IEC 62040-2	Uninterruptible power systems (UPS). Electromagnetic compatibility (EMC) requirements
BS EN IEC 62485-1	Safety requirements for secondary batteries and battery installations. General safety information
BS EN IEC 62485-2	Safety requirements for secondary batteries and battery installations. Stationary batteries
IEC 60331-2	Tests for electric cables under fire conditions. Circuit integrity. Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0,6/1,0 kV and with an overall diameter not exceeding 20 mm
IEC 60331-3	Tests for electric cables under fire conditions. Circuit integrity. Test method for fire with shock at a temperature of at least 830°C for cables of rated voltage up to and including 0,6/1,0 kV tested in a metal enclosure

48.2 General

Safety services shall be designed, selected, installed and tested in accordance with BS 7671.

Supplies for safety services shall be via one of the following, as specified in the drawings and schedules:

- A central power supply (CPS)
- A low power supply source
- An Uninterruptible Power Supply UPS.

The following meanings are attached to the changeover time of the supply in the schedules:

- No-break: an automatic supply which produces a continuous supply within specified conditions during the period of transition, for example as regards variations in voltage and frequency.
- Very short break: an automatic supply available within 0.15 s
- Short break: an automatic supply available within 0.5 s
- Normal break: an automatic supply available within 5 s
- Medium break: an automatic supply available within 15 s
- Long break: an automatic supply available in more than 15 s, but less than 5 minutes.

Where the schedules do not specify a changeover time, the changeover time of a supply to a safety service shall be compatible with the equipment, and its intended function, to maintain the specified operation.

Supplies for fire detection and alarm systems, automatic release mechanisms for fire protection equipment, voice alarm systems, and emergency voice communication systems, shall comply with the relevant parts of BS 5839.

Supplies for emergency lighting systems shall comply with the relevant parts of BS 5266 and BS EN 1838.

48.3 Supplies for fire suppression, fire-fighting, emergency lighting and smoke control

All equipment for the safety service shall be selected to maintain the duration stated in the schedule or particular specification for the services supplied. Unless otherwise stated in the schedules and drawings, a duration of four hours (240 minutes) shall be assumed.

48.4 CPS and UPS

CPS shall comply with BS EN 50171. UPS for safety services shall comply with BS EN IEC 62040-1, BS EN 62040-2 and BS EN 62040-3

Unless otherwise stated in the schedules and drawings, all batteries used in UPS or CPS for safety services shall be heavy duty industrial type cells complying with:

- BS EN 60623 for vented nickel-cadmium batteries;
- BS EN 60896-11 for vented lead-acid stationary batteries;
- BS EN 60896-21 and BS EN 60896-22 for valve-regulated sealed lead-acid stationary batteries.

The minimum design life in the ambient temperature stated in the particular specification shall be at least 10 years.

All batteries for safety services shall be accessible only to skilled or instructed persons, and housed in accordance with BS 7671, BS EN IEC 62485-1 and BS EN IEC 62485-2.

48.5 Low Power Supply Sources

Low power sources shall be limited to 1,500 kVAh with a maximum duration of 3 hours. Cells of batteries shall be heavy duty industrial type cells complying with:

- BS EN 60623 for vented nickel-cadmium batteries;
- BS EN 60896-11 for vented lead-acid stationary batteries;
- BS EN 60896-21 and BS EN 60896-22 for valve-regulated sealed lead-acid stationary batteries.

The minimum design life in the ambient temperature stated in the particular specification shall be at least 5 years.

All batteries for safety services shall be accessible only to skilled or instructed persons, and housed in accordance with BS 7671, BS EN 62485-1 and BS EN 62485-2.

48.6 Generator sets for safety services

A generating set used for safety services shall additionally comply with BS 7698-12.

48.7 Wiring systems selection and installation for Safety Services

Circuits of safety services shall be fire resisting and shall not pass through any zones exposed to explosion risk. They shall only pass through locations where there is a risk of fire where approved by the Engineer. The following wiring systems shall be used for circuits of safety services:

- Mineral insulated cable complying with BS EN 60702-1, BS EN 60702-2 and BS EN 60332-1-2
- Fire-resistant cables complying with BS EN 60332-1-2 and either IEC 60331-1, IEC 60331-2 or IEC 60331-3
- Fire-resistant cables complying with test requirements of BS EN 61332-1-2 and either BS EN 50200 and BS 8434-2, or BS 8491.

The wiring system shall maintain the necessary fire and mechanical protection for the specified duration and shall be installed so that the circuit integrity is maintained in a fire.

Where indicated on the schedules and drawings indicate the safety services shall be installed in constructional enclosures to maintain fire protection, or installation in separate fire compartments.

Selection and installation of power and control cables for safe safety and firefighting applications shall comply with BS 8519.

48.8 Integration, control and monitoring

The condition of sources for safety services shall, be monitored, and indicated:

- On a local control indicator panel complying with BS EN 60073.
- Centrally by the building management system.

As a minimum, the following conditions shall be monitored and indicated:

- Ready for operation
- System fault condition
- System supplying power
- State of backup battery or generator fuel level

The building management system shall alert the duty facility manager when the supply to the safety services is in a fault condition, or the backup battery or generator fuel level is no longer capable of meeting the backup duration.

49.0 Electrical Management and Control Systems

49.1 Summary of Standards

The following table lists the standards relevant to this section. Wherever reference is made to a British Standard (BS), a British Standard Institution harmonized equivalent European Standard may be acceptable if agreed with the Engineer. If the project is not located in the UK then any British Standards listed shall be replaced with the equivalent National Standards. Each type of work/equipment/material selected shall comply fully with the most recent edition of the Standards.

STANDARD	TITLE
EMC Directive 2014/30/EU	EEC EMC emission standards
BS EN 62305-1	Protection against lightning – Part 1: General principles
BS EN 61643	Low-voltage surge protective devices
EEMUA 191	EEMUA 191 guidance

49.2 General

For requirements of BMS (Building Management System) and Associated control systems refer to Section 12 of P.100000-RED-XX-XX-SP-M-8000 Standard Specification for Mechanical Engineering Services.

49.3 Materials and Workmanship

This section sets out the standards for materials and workmanship for Power Management System (PMS) and the Energy Management Systems (EMS).

Where the BMS System provides the overall supervisory monitoring and control of all MEP services for the complete building, the PMS and EMS systems shall connect into the site-wide BMS system network through compatible interfaces to provide the monitoring and control of the EMS and PMS systems required by the BMS system.

For system structure, networking, system security, hardware, HMI, graphics workstations, headend requirements, refer to the Section 12 of P.100000-RED-XX-XX-SP-M-8000 Standard Specification for Mechanical Engineering Services.

49.4 Energy Management System (EMS)

49.4.1 General Overview

The Contractor shall design, supply, deliver to site, install, connect, test and commissioning all controls and monitoring to form a complete working installation in accordance with this specification to the satisfaction of the employer's agent.

Inspection and approval of equipment by the Employers Insurance Company, required by British Standard Specifications and by this Specification shall be provided.

All site works required i.e. Panel installation, SAT, first power up or commissioning support shall be included in the tender price.

The Energy Management System (EMS) shall control and monitor the building services as detailed within this specification, and the project drawings, providing feedback of the site's energy performance for analysis, and

full control of the plant connected as described. The EMS shall comprise all the necessary intelligent EMS Controllers, operators' terminals and peripherals connected by a hard-wired network or a network deemed suitable i.e. Ethernet using recognised TCP/IP protocols, over copper or Fibre. It shall be supplied, configured, installed and commissioned by the EMS specialist and the clients' Engineers shall be trained by the manufacturer in its full use.

The Contractor shall provide control wiring diagrams, control panel to plant/control devices interconnecting wiring diagrams and proposed control descriptions prior to manufacture, as well as "as installed" diagrams and record drawings.

The Contractor shall provide supervision of the whole installation, commissioning, instruction as required, and shall guarantee the system.

The Contractor shall provide software strategy for each controller to provide control and monitoring functions as detailed in the specifications.

The Contractor shall provide software Engineering of the onsite supervisor to create building and plant schematics, alarms, and energy profiles, together with installing copies of all schematics and alarms etc, on multiple workstations.

The Contractor shall furnish all materials, including all computer hardware and software, operator input/output peripherals, field hardware panels, sensors and field control devices, power wiring and containment, control wiring and containment, network wiring and containment and O&M documentation.

The hardware supplied shall consist of physical components that are built to established industry standards, which support the communications scheme of the specified system, and do not require customisation to meet the requirements of the Specification. All hardware and software provided under this contract shall be held in the inventory of both the manufacturer and the installing Contractor and shall be considered items of standard manufacture. Devices that are currently out of production or are being phased out of production within a twenty-four-month period from the date of this document shall not be considered for this project.

The Contractor shall be responsible for all design, Engineering, supervision, installation, labour, calibration, software programming, commissioning, demonstrating and training required to provide a complete and fully operational system in accordance with the specification, CIBSE Guide H, CIBSE commissioning Code C (or national equivalent) and the current edition of the Building Regulations for the country of installation.

The Contractor shall comply with all requirements of this specification which should be read in conjunction with all other specifications and associated drawings.

Any discrepancies or deviations from this specification must be identified at Tender Stage and approved by the Engineer in writing.

All Field Devices, including meters, Current and Voltage Sensors (Transformers,) switchgear auxiliary contacts, etc, shall be fitted with typed reference labels, suitable for the device and environment. Field Devices within non-technical occupied areas shall be provided with discrete concealed labels.

All wiring and cabling, including within factory-fabricated panels shall be labelled at each end within 50 mm of termination. Where a tagging or naming convention is provided, then this should be followed otherwise as a minimum the EMS address or termination number should be used.

Identify all other control components with permanent labels. All plug-in components shall be labelled such that removal of the component does not remove the label.

49.4.2 System Structure

The Energy Management System head end (SCADA) shall be PC based and have networked distributed intelligence structure.

The structure of the Energy Management System will require that a manufacturer's stand-alone or networked product, shall have the capability to communicate and be fully compatible both at a forward and backward level, across the manufacturer's product range. This also includes the requirement for future proofing without detriment to the new or the manufacturer's own, existing Energy Management System.

This shall include the capability to communicate with, and the support of, a manufacturer's own product whose age is less than ten years, thus demonstrating a commitment towards protecting the client's investment.

The manufacturer/supplier must, at the client's request, be able to demonstrate such a commitment through an existing system or equivalent demonstration.

The EMS system shall:

1. Communicate to user terminals and other sites via appropriate firewalls and Wide Area Network (WAN)
2. Have the capability to communicate over the internet
3. Have the facility to save and download alarms and trends for inspection
4. Have autonomous local and wide area networks, electrically and operationally independent of each other, which are capable of future expansion
5. Be able to support any number of user terminals, either LAN, WAN or locally connected. The interchange of data between network devices shall be without recourse to any central or host computer. LAN's shall be installed on each floor level as a minimum and split logically on floor plates where each floor level is designed to be sub-tenanted
6. Have in-built protection against site local lightning strikes, mains surges and external EM radiation causing the total malfunction of the system. All components shall comply with EEC EMC emission standards
7. Where any control panel is located externally or is located internally but has any connected cabling containing electrical conductors which runs externally, the panel shall be provided with filtering and a Surge Protective Device on each cable in accordance with BS EN 61643-11. The BMS Contractor shall liaise with the Electrical Contractor prior to final selection of SPD device to ensure compatibility of all SPD's installed within the Electrical Power Distribution scheme to the following standards:-
 - a. BS EN 62305-1 - Protection against lightning – Part 1: General principles
 - b. BS EN 61643 - Low-voltage surge protective devices
8. Have monitoring facilities to detect failed EMS Controllers and other network communication devices. All EMS Controllers and other network devices shall incorporate a watchdog circuit which shall isolate the device from the network in the event of local power failure or device failure. This shall not adversely affect other EMS Controllers or LAN's. EMS panel and network system faults shall also alarm on the head end. These shall include, but not limited to, MCB open, PSU fault, Communication fault, surge protection fault and comms fault
9. Have system devices which shall have the capability to communicate via the network, to send alarms, monitor or control data and provide information on a request or send basis. A message shall be acknowledged by the receiving device. If not acknowledged, the message shall be repeated by the sender. It shall not be possible to "Choke" the network due to flooding of alarms on the system. See EEMUA 191 guidance
10. An alarm filtration facility shall exist to either delay or re-prioritise each alarm if the original event has not been acknowledged. Alarms shall be based on time to respond and the consequence of the fault
11. All alarms shall be time stamped and be stored for historical review and shall be downloadable for export
12. A clear rationale shall be agreed with the Engineer to agree an alarm strategy for the site

49.4.3 System Security

System architecture shall be designed against a threat assessment as per standard BS EN 62443-2-1 Security for Industrial Control Systems. The responsibility for cyber security is by the Contractor unless the client states otherwise.

A system wide password/pin facility shall be incorporated with programmable levels of access assigned to the client's individual system operators and Engineers. The password structure shall ensure protection to change any set point, sequence selection, control and monitoring parameter or any equipment configuration. A common overall system password set, and procedure shall be provided whether access is gained from operators' terminals, portable terminals or keypads on single or multi-site schemes. Manual overrides and set point adjustments shall have individual programmable levels to control access according to the responsibility and competence of the individual to the priority of the adjustment. The highest level of password shall access the Engineer's utility for both EMS Controllers and user terminals configuration. At operator terminals a user logging-on shall be recorded with time/date. Logging off shall be by command or time-out from non-use of the keyboard or mouse with the event again recorded.

The system Engineer shall be able to add/delete operators and change levels of their access. Security at this high level will be achieved by software issued to the client at hand-over. Users shall be able to change their passwords/PIN numbers at will.

49.4.4 OEM (Original Equipment Manufacturer) supplied components

Where EMS Components are supplied and mounted within OEM supplied packaged plant (e.g. switchgear UPS, Generators etc) the Contractor shall supply all the necessary interface equipment and cabling and shall complete all the necessary work to connect to the OEM package. He shall not change any pre-configuration of the OEM supplied control/monitoring strategies without written permission of the unit manufacturer.

49.4.5 Operator Workstation Software

All main operator station software shall run under the current edition of Microsoft "WINDOWS" operating system (English version) and MS office professional, unless otherwise specified.

All appropriate licences shall be included to support the system software i.e. SCADA, historical trend, data archiving required. The licences shall support the number of I/O in the schedule, plus the addition of 20% spare.

All licences shall be transferred to the client on completion of the project.

The EMS supervisory software shall be supplied as a complete package with back-up electronic copies, and O&M instructions. All text on both software and paper shall be dual language on all projects outside the UK.

Schematic diagrams showing the layouts and menu forms shall be supplied prior to data entry for approval by the Client.

An Engineer's utility allowing new displays to be created and changes made to those formatted shall be supplied. The use of this programme will be considered for ease of use and its operation shall be incorporated in the Engineers training.

49.5 Power Management System (PMS)

The Contractor shall design, supply, deliver to site, install, connect, test and commissioning all controls to form a complete working installation in accordance with this specification to the satisfaction of the employer's agent.

Inspection and approval of equipment by the Employers Insurance Company, required by British Standard Specifications and by this Specification shall be provided.

All site works required i.e. Panel installation, SAT, first power up or commissioning support shall be included in the tender price

The Power Management System (EMS) shall control and monitor the electrical services systems as detailed within this specification, and the project drawings, providing the control and monitoring functions of the electrical distribution described within equipment particular specifications.

The PMS shall be standalone systems provided as part of the electrical equipment to provide management and control between the electrical equipment such as:

- LV switchgear
- MV switchgear
- Rotary Generators
- Uninterruptible power supplies
- Renewable Energy Systems

49.6 Metering

Metering or Sub-Metering shall be provided to ensure full compliance with the current edition of the Approved Document Part L of the Building Regulations.

For further requirements for metering, refer to sections of electrical equipment within this specification.