Construction & Engineering Services Ltd

Electrical Specification

Shuttleworth College
Bedford College

Date:	1st December 2023	**Revision:**	T00
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Introduction

The project involves the decarbonisation of part of the Shuttleworth college site, the project is part funded by the SALIX Public Sector Decarbonisation Scheme (PSDS), the project has been split into various elements of works as follows:

- Halls of Residence – SALIX PSDS; these works contain any elements related to the replacement of the heating systems to the Halls of Residence (HOR)
- Halls of Residence – Fit Out; these works contain any elements related to the refurbishment of the HORs
- SALIX PSDS Infrastructure – These works contain the infrastructure upgrade works across the site to include the new electrical sub station, new Air Source Heat Pump (ASHP) plantroom, new district heating pipework system, new heating to the Russell Hall Complex and LRC building.

At this stage only the Halls of Residence package of works have been issued for tender.

This document comprises the Electrical Services Specification that is divided into two main parts:

- **SECTION A -** The General Conditions of the project that describes the site, nature of contract and how the project shall be managed by the contractor.
- **SECTION Y -** The Electrical materials and workmanship specification define the minimum technical requirement and quality of workmanship required to successfully meet contractual obligations and client expectations.

All deviations from the requirements of this document shall be stated in the bid documentation. In the absence of such a statement, it shall be understood that all requirements of this specification are fulfilled without exception.

This document shall be read in conjunction with the equipment specifications, tender drawings, building information model, schedules, lists, contractual documentation, letters and any other information issued with this tender package.

General Conditions

A10 – General Particulars

Project Name: Shuttleworth College PSDS & Halls of Residence Fit Out

Client: Bedford College

Engineer: Panda CES Ltd, T: 01908 991130, www.pandaces.co.uk
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A11 – Tender and Contract Documents

The tender documents with respects the Electrical systems are detailed on the Document Issue Notice reference 02-15-E-DIN issued at tender.

A12 – The Site/Existing Building

Site Address: Shuttleworth College, Old Warden Park, Biggleswade, SG18 9DX.

A13 – Description of the Works & Common Design Criteria

The electrical services work for the HOR works will comprise the supply, delivery to site, installation and testing and commissioning the electrical services as follows and detailed below:

- Stripping out of existing lighting, power & data systems to the Milner, Ongley & Patworth Blocks
- Primary and emergency lighting
- Small power installation
- Containment Installations
- Telecoms and data wiring
- Mechanical services power wiring
- Earthing and bonding

The works shall be carried out in accordance with the British standards relevant at the time of tender, the materials and workmanship standards detailed in this specification, terms and conditions of the main contract, main contract program, layout drawings, single line diagrams, building information model, schedules, and lists.

All equipment, plant, materials, and specialist systems installed under this contract shall be as detailed on the drawings, schedules and in this specification. Where no manufacturers have been listed for items being supplied, the Contactor shall select one of their choosing, however, it must comply with the requirements of the specifications and standards list in this document.

Within this contract there are elements that require contractor design (refer to section A31) and specialist sub-contractor design. Any drawings or specifications issued at tender related to these elements are indicative to communicate the design intent only. The specialist contractor shall allow within the tender costs to design, supply, install and commission these elements and provide full construction issue drawings and specifications for approval by the engineer before commencing works.

Therefore, the following specialist electrical Contractor Design Portions have been identified in the main contract:

1. Lighting Control Systems

The Contractor shall employ the listed specialists below to assist in the execution of the works.

NOMINATED SPECIALISTS				
Name	**Service**	**Company**	**Telephone**	**Email**
Martin Snarey	Lighting Controls	Lighting Controls UK Ltd	07772 660174	martin.snarey@lightingcontrols.ltd.uk

This contract will be undertaken on a Design and Build Basis and therefore the contractor is fully responsible for applying due diligence to the Tender design, developing the design from Stage 4 to completion and for all specialist sub-contractor designs required.

Any drawings or specifications issued at tender are indicative to communicate the design intent and specific client requirements only. The contractor shall allow within the tender costs to design, supply, install and commission the electrical services and provide full construction issue drawings and specifications for approval to the engineer before commencing works.

Common Electrical Design Criteria

Power

The technical requirements of the electrical power supplies for the facility.

Low Voltage (LV) System (400 Volt)

- 400 volts TNC-S arrangement
- 3 phase, 4 wire plus earth, 50Hz

Low Voltage System (230 Volt)

- 230 volts
- 1 phase, 2 wire and earth, 50Hz

Overall Voltage Drop Limits - The maximum volt drop on the distribution system from the point of supply to the furthest power outlet shall not exceed 4%. Lighting will be limited to 3%.

Lighting

Lighting Performance – As per CIBSE LG 5 Table 5.1
Daylighting Performance – As per CIBSE LG 5 Table 5.2
Exterior Lighting Performance – As per CIBSE LG 5 Table 5.5

A20 – The Contract/Sub-Contract

Please refer to the main contract documents issued for contract details.

A31 – Provision, Content and use of Documents

Design Software

The project has been designed using a Autocad 2020 and therefore all contractor drawings (working, as installed etc) shall be undertaken using the same software. The tender stage cad file shall be issued to the contractor by the engineer and the contractor shall develop this to prepare all co-ordination drawings, installation drawings and represent the as installed systems on record drawings which shall be provided to the client as part of the O&M information upon completion of the project. The drawing outputs issued by the contractor (working, as installed etc) from the cad file shall be issued in .pdf format and also .dwg if requested.

Contractors Design Obligations

The M&E contractor will be responsible for providing the following content or documentation as part of the construction phase design of the project:

1) Develop the Tender design to completion.
2) Detail all access and BWIC requirements, including access in false ceilings and ducts, for maintenance. Provide fully dimensioned and annotated drawings to the Main Contractor.
3) Locate and provide detailed design for all brackets and supports to include any non-penetrative support.
4) Ensure suitable access to all valve, damper and plant locations for easy access of maintenance personnel. Do not install electrical services that impede access to any Mechanical or Electrical items.
5) Prepare detailed electrical wiring diagrams of all equipment supplied showing all interconnections between equipment to enable all wiring installations to be undertaken.
6) Design the electrical containment systems ensuring adequate capacity is provided. Co-ordinate the location and route of the electrical containment systems.
7) Prepare distribution and panel board schedules for approval by the engineer.
8) Design and select all anti-vibration mountings to ensure vibration is not carried over to the building structure; vibration from equipment shall be imperceptible.
9) Ensure adequate provision and suitable location of test points, control sensors, detectors, thermostats and gauges.
10) Size cable terminations to all items of equipment.
11) Ensure fuse sizes installed to plug connectors are appropriate for the rating of the connected equipment.
12) Design cable and containment terminations to all items of equipment.
13) Design and dimension electrical switchgear to ensure that cable entry is acceptable in the selected location and safe operation and access for installation and maintenance can be provided.
14) Design earthing and bonding systems for all installations as required.
15) Ensure cable sizes indicated on the detailed design information are not invalidated by the selection of alternative routes during co-ordination or selection of alternative manufacturer's equipment.
16) Make recommendation/advise on all platforms, access covers, gratings and ladders required for suitable access for maintenance.
17) Ensure all alternative proposals including value engineering exercises are fully designed before submitting for approval.
18) Note and advise the main contractor of all acoustic and fire stopping required to facilitate the works.

19) Any changes to the detailed design drawings and information required as part of a variation or change from specification post contract award shall be undertaken by the contractor and information issued to the CA for approval/comment.
20) Design, supply and install all builders work openings <50mm required to facilitate the services installations.

The Main Contractor shall be responsible for providing the following content or documentation as part of the construction phase of the project:

1) Check the provision for and accuracy of the builder's work information during the tender period, make all necessary allowances in the tender return for all Builders Work In Connection (BWIC) with the Mechanical & Electrical Services.
2) Detail the final or supplementary builders work information based on manufacturers or sub-contractors design or co-ordination information and provide fully dimensioned drawings.
3) Design, supply and install all platforms, access covers, gratings and ladders required for suitable access for maintenance.
4) Design and undertake all acoustic and fire stopping required to facilitate the works.
5) Design, supply and install all builders work openings >50mm required to facilitate the services installations.

Drawing Definitions
The definitions of technical terms associated with the engineering services installations are those included in:

- CIBSE, IOP and BSRIA Technical Publications
- Loss Prevention Council - Rules for Automatic Sprinkler Installations
- BS 7671 - Requirements for Electrical Installations (IEE Wiring Regulations).
- British Standards, including Codes of Practice.
- Associated Statutory Acts.

Where used in the documentation the following definitions apply:

- Duct: An enclosed space specifically intended for the distribution of services, with direct access for personnel.
- Trench: A covered horizontal service space in the floor or ground with access from above.
- Cavity: A space enclosed within the elements of a building within which services are installed, e.g. the space between ceiling and floor above. See Building Regulations.
- Service Areas: Includes areas within a building with limited finishes such as loading bays, car parks etc.
- Concealed Services: Includes installations within ducts, trenches or cavities.
- Exposed Services: Includes installations within plant rooms, outdoors or unprotected within service or occupied areas.
- System: System means all equipment, accessories, controls, supports and ancillary items, including supply, installation, connection, testing, commissioning and setting to work necessary for that section of the Works to function.
- Services: Services means the inclusion of one or more systems.

Tender drawings mean drawings listed in the Document Issue Notice (DIN) referenced in section A11.

The tender drawings show the general arrangement of the Engineering Services to be provided and the inter-relationship of the Works with work to be installed by others.

Sketch drawings, schematic drawings, detailed design drawings, co-ordination drawings, installation drawings, installation wiring diagrams, shop drawings, manufacturer's drawings, manufacturer's certified drawings, record drawings, builder's work drawings are as defined in the BSRIA TN 21/97 Appendix A.

The responsibility for developing the design and issuing the drawings defined below is detailed in the following table:

Drawing Type	Engineer	Contractor
Sketch Drawings	✓	
Schematic Drawings - Tender	✓	
Schematic Drawings – Construction Phase		✓
Detailed Design Drawing	✓	
Co-Ordination Drawing		✓
Installation Drawing		✓
Installation Wiring Diagram		✓
Shop Drawings		✓
Manufacturers Drawings		✓
Manufacturers Certified Drawings		✓
Record Drawings		✓
Builders Work Drawing - Design stage	✓	
Builders Work Drawing - Installation stage		✓
Controls Logic Diagrams		✓
Switchgear, Starter and Control Instrumentation panel drawings		✓
As Installed Drawings		✓
Plantroom Schedules & Schematics		✓

Sketch Drawings - Line diagrams and layouts indicating basic proposals, location of main items of plant, routes of main pipes, air ducts and cable runs in such detail as to illustrate the incorporation of the Engineering Services within the Project as a whole.

Schematic Drawings - A line diagram describing the interconnection of components in a complex system. The main features of a schematic drawing are as follows:

- A two dimensional layout drawing with divisions to show the distribution of the system between building levels. Or an isometric style layout indicating the distribution of systems across individual floor levels. The drawing is not necessarily constructed to scale. Include all functional components which make up the system, i.e. plant items, pumps, fans, valves, strainers, terminals, electrical switchgear, distribution and components.
- Symbols and line conventions in accordance with BS EN ISO 11091 Recommendations for symbols and other graphic conventions.
- Label the drawing with appropriate pipe, duct and cable sizes where these are not shown elsewhere.
- Indicate components which have a sensing and control function and show the links between them, e.g. building management systems, fire alarms and HV controls.

- Identify the major components indicated on the schematic drawing so that their whereabouts in specification and on other drawings can be easily determined.
- Commissioning specification

Include all data essential to testing and commissioning including volumetric flow rates, design total pressure losses at equipment, locations of dampers, valves and flow measuring stations, electrical fault levels, current ratings, short circuit capacities and tripping times.

Detailed Design Drawing - A drawing showing the intended locations of plant items and service routes in such detail as to indicate the design intent. The main features of detailed design drawings should be as follows:

- Plan layouts to a scale of at least 1:100.
- Plant areas to a scale of at least 1:50 and accompanied by cross-sections.
- The drawing will not indicate the precise position of services, but it should be feasible to install the services within the general routes indicated. It should be possible to produce co-ordination drawings or installation drawings without major re-routeing of the services.
- Represent pipework by single line layouts.
- Represent ductwork by either double or single line layouts as required to ensure that the routes indicated are feasible.
- Indicate on the drawing the space available for major service routing in both horizontal and vertical planes.

Co-Ordination Drawing – A drawing showing the inter-relationship of two or more engineering services and their relation to the structure and building fabric. The main features of a co-ordination drawing are as follows:

- Plan layouts to a scale of at least 1:50, accompanied by cross-sections to a scale of at least 1:20 for all congested areas.
- A spatially co-ordinated drawing, i.e. no physical clashes between the system components when installed at the scaled-off positions shown on the drawing. Provide dimensions in areas where tolerances are minimal.
- Make allowance for the service at its widest point for spaces between pipe and duct runs. Allow for insulation, standard fitting dimensions and joint widths on the drawing.
- Make allowance for those plant items specified by the designer and identified in the design specification.
- Make allowance for installation working space and space to facilitate commissioning and maintenance.
- Indicate positions of main fixing points and supports where they have significance to the structural design.
- Arrange the services so that it is possible to demonstrate a feasible sequence of installation.
- Support the drawing with individual services drawings for clarity.
- Plantroom layouts to a scale of at least 1:20, accompanied by cross-sections and elevations to a scale of at least 1:20.

Installation Drawing - A drawing based on the detailed drawing or co-ordination drawing with the primary purpose of defining that information needed by the tradesmen on site to install the works. The main features of installation drawings should be as follows.

- Plan layouts to a scale of at least 1:50, accompanied by cross-sections to a scale of at least 1:20 for all congested areas.

- A spatially co-ordinated drawing, i.e. no physical clashes between the system components when installed at the scaled-off positions shown on the drawing.
- Make allowance for inclusion of all supports and fixings necessary to install the works.
- Make allowance for the service at its widest point for spaces between pipe and duct runs. Allow for insulation, standard fitting dimensions and joint widths on the drawing.
- Make allowance for installation details provided from shop drawings.
- Make allowance for installation working space; space to facilitate commissioning and space to allow on-going operation and maintenance in accordance with the relevant health and safety requirements.
- Make allowance for plant and equipment including those which are chosen as alternatives to the designers specified option.
- Provide dimensions where the positioning of services is considered to be important enough not to leave to the tradesmen onsite.
- Plantroom layouts to a scale of at least 1:20, accompanied by cross-sections and elevations to a scale of at least 1:20.

Installation Wiring Diagram - Drawing showing the interconnection of electric components, panels etc in accordance with the design intent indicated in the schematic drawings and incorporating the details provided on manufacturer's certified drawings.

Indicate the following; maximum electrical loading for each supply cable; cable termination facilities; and cable identification and all terminal numbers.

Shop Drawings - Drawing prepared by a fabricator or supplier unique to the project. Including supplier's drawings for ductwork, pre-fabricated pipework, sprinkler systems, control and switchgear panels and associated internal wiring.

Manufacturers Drawings - Drawing provided by a manufacturer or supplier to indicate a typical representation of the product, components or plant items to be supplied for a particular project.

Manufacturers Certified Drawings - Drawing provided by a manufacturer or supplier to indicate details of the product, components or plant items and which the manufacturer or supplier guarantees the supplied equipment will comply with.

Record Drawings - Drawing showing the building and services installations as installed at the date of practical completion. The main features of the record drawings should be as follows:

- Provide a record of the locations of all the systems and components installed including pumps, fans, valves, strainers, terminals, electrical switchgear, distribution and components.
- Use a scale not less than that of the installation drawings.
- Have marked on the drawings the positions of access points for operating and maintenance purposes.
- The drawings should not be dimensioned unless the inclusion of a dimension is considered necessary for location.

Builders Work Drawing - Design stage

- A drawing to show the provisions required to accommodate the services which significantly affect the design of the building structure, fabric and external works. Also drawings (and schedules) of work to be carried out by building trade, and required to be costed at the design stage eg. plant bases.

Builders Work Drawing - Installation stage

- Drawing to show requirements for building works necessary to facilitate the installation of the engineering services (other than where it is appropriate to mark out on site).

Controls Logic Diagrams - Diagrams, drawings and/or schematic details of all control components and instruments showing the layout with each item uniquely identified together with a description of the controls operation and details of the associated interlocking.

Switchgear, Starter and Control Instrumentation panel drawings - Drawings showing the construction and internal wiring diagrams of the starters, panels and/or other devices.

As Installed Drawings - Drawings/records retained on site to record the progress of and any site modifications to the Works including any changes to software.

Plantroom Schedules & Schematics - Frame the following under clear perspex and hang in each plant room and any other appropriate location.

- Schematic drawings of circuit layouts showing identification and duties of equipment, numbers and locations, controls and circuits.
- Valve schedules in the form of printed sheets showing the number, type, location, application/service and symbol, and normal operating position of each valve.
- Control schematics.
- Location of mechanical and electrical plant and equipment items.
- First aid instructions for treatment of persons after electric shock.
- Location of isolating switch for electricity supply.
- Emergency operating procedures and telephone numbers for emergency call out service applicable to any system or item of plant and equipment.
- All other items required under Statutory or other regulations.
-

A32 – Management of the Works

The engineer is providing a Clerk of the Works service to the client as part of this project to provide a collaborative arrangement to help with on-site co-ordination, installation quality, compliance with specification and effective commissioning of all M&E systems. To provide this service effectively collaborative working and communication with all trades regardless of contractual commitments is required.

Where the main contractor appoints a combined Mechanical & Electrical contractor to undertake the works detailed in this specification, the M&E contractor shall appoint a contracts manager to co-ordinate all M&E trades and be the Specific Point Of Contact (SPOC) for the engineer during the works. No intermediary from the main contractor will be permitted under this arrangement.

Where the main contractor appoints separate Mechanical, Electrical and Plumbing contractors to undertake the works detailed in this specification, the main contractor shall appoint a competent technical services manager to co-ordinate all M&E trades and be the Specific Point Of Contact (SPOC) for the engineer during the works.

The engineer reserves the right to communicate (not instruct) directly with all trades working on any element of this project regardless of any contractual arrangements, any attempts by the main

contractor to limit communication is not permitted. The engineer may request at any point for a direct representative from any trade to attend a design team meeting.

A33 – Quality Standards and Control

All works shall be carried out in accordance with the British standards relevant at the time of tender, the materials and workmanship standards detailed in this specification, terms and conditions of the main contract, main contract program, layout drawings, single line diagrams, building information model, schedules, and lists.

In additional, the contractor shall have in place their own quality standards and control system which shall be applied to all works before offering systems for inspection/handover to the engineer.

The engineer reserves the right to request a copy of the contractor's quality standards (such as method statements, system installation check lists, commissioning checklists, pre-commissioning checklists, close out certificates, works sheets etc) and quality control systems prior to inspecting any works.

A35 – Specific Limitations on Method/Sequence/Timing

The contractor shall ensure all systems are installed in a timely sequence and do not impose additional requirements on other trades that could have reasonably been avoided if a suitable sequence of work had been followed. No claim for contract variations will be accepted for consequences associated with out of sequence working. All contractors should be aware of their legal commitments to use all reasonable endeavours to minimise the cost implications for all other trades resulting from out of sequence working.

Commissioning – Commissioning of all electrical and control systems must be correctly sequenced and managed within the programme in a timely fashion. Time in the programme must have dedicated lines for witnessing the completed commissioning results by the engineer (completed commissioning not ad hoc individual items as and when they are completed), and another separate line for functionality testing of the completed systems by the engineer. A minimum notice of 1 working week is required for attendance by the engineer for both witnessing and functionality testing and the contractor shall set out a full agenda of the different elements to be witnessed and functionality tested on each visit, this shall be issued 2 working days before the scheduled visit or the visit will be cancelled.

Functionality testing can only be completed within an unoccupied building. If commissioning witnessing and functionality testing is not 100% complete and signed off by the engineer prior to handover the contractor must leave a permanent site based electrical engineer on site (Mon-Fri 08:00 to 17:00) to routinely check the performance and operation of all electrical systems on behalf of the client, providing a daily checklist of monitored items and current performance. This clause is included to prevent contractors treating the completion of commissioning, witnessing and functionality testing of electrical systems as a snag or defect.

1st Fix installation – Electrical containment cannot be first fixed before the ductwork or pipework systems unless fully co-ordinated working drawings have been approved by the engineer and the installation sequence has been fully assessed by the main contractor to ensure the mechanical systems are not impeded or affected detrimentally by the electrical containment systems. The basis for this clause is that electrical containment is easier to route than pipework and ductwork systems (before wiring is fitted to containment).

Specific Project Sequencing: N/A

A36 – Facilities and Temporary works/services

No facilities or temporary works/services are anticipated for the M&E aspects of this project. The main contractor may have other requirements to comply with the H&S requirements of the project, site fire protection and security during the works. These will need to be detailed by the main contractor during the tender period and allowance made to effect the employers requirements.

These works and are not dealt with in the Mechanical & Electrical tender documents and shall be included and costed by the Contractor within the Preliminaries section of the Contract Sum Analysis.

A37 – Operation & Maintenance of the finished building

The M&E contractor shall allow for all Planned and Preventative Maintenance to fully comply with the SFG20 maintenance standard and the requirements of the product manufacturers recommendations for all M&E systems installed under this contract for the first 12 months after the date of practical completion. This will ensure that no defects arising within the first 12 months can be attributed to the client not undertaking the necessary maintenance.

The contractor shall provide 2no. hard copies of an Operating and Maintenance manual for all M&E systems installed in the project to include but not be limited to:

1) Description of Operation
2) Schedules
3) Record Drawings (Printed at full size)
4) Commissioning & Testing Documentation
5) Asset list of all Mechanical & Electrical equipment installed to include the Unique Identifier, Description, Manufacturer, Model Number, Serial Number, Date of Installation, Applicable SFG20 Routines
6) SFG20 compliant maintenance routines and project specific PPM schedule
7) Quotations for post project maintenance
8) Manufacturers O&M information (product specific only to equipment installed, not generic and not a catalogue)
9) USB pen drive with all O&M documentation fixed within folder
10) A3 maintenance schedule/matrix detailing each item and frequency, example shown below;

Item	**Maintenance Provider**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Other**
Emergency Lighting	College	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Dist. Boards	Electrician X													Yearly
Water Boilers	Electrician X													Yearly
Timers	Electrician X			✓						✓				
Emergency Stops	Electrician X	✓			✓			✓			✓			
Toilet Extract	Electrician X	✓			✓			✓			✓			
Fire/Smoke Dampers	Electrician X	✓			✓			✓			✓			
Fire Alarm	Company X	✓			✓			✓			✓			

Gas Detection	Company Y	✓			✓			✓			✓			
Lighting	Electrician X													Yearly
External Lighting	Electrician X	✓						✓						
Earthing	Electrician X	✓						✓						
Heat Emitters	Company Z	✓			✓			✓			✓			
Electric Heater	Company Z													Yearly
Hot Water Cylinders	Company Z	✓			✓			✓			✓			
Light Switching	Electrician Y	✓						✓						
Lightning Protection	Electrician Y													Yearly
Trace Heating	Electrician Y	✓								✓				

The contractor shall also provide framed Plantroom Schedules & Schematics, Electrical Distribution Schematics and Distribution Board Schedules fixed within plantroom areas and electrical distribution cupboards and switchrooms.

A53 – Works by Statutory Authorities/Undertakers

There are no utilities or works by Statutory Authorities required as part of this project.

A54 – Provisional Work Items

Provisional Sum items shall be detailed in the Electrical Contract Sum Analysis.

A55 – Dayworks

No daywork items are anticipated at this stage of the project, the contractor is to identify the dayworks rate for the following trades as part of the tender return:

- Contracts Manager
- Electrician
- Fire Alarm Engineer
- Security Engineer
- Controls Engineer
- Plumber
- Pipe Fitter
- Air Conditioning Engineer
- Ductwork Fitter
- Insulation Fitter
- Commissioning Engineer
- Controls Engineer
- Apprentice/Non-Skilled Tradesmen

A64 – General Conditions for the Building Services Contract

Refer to the main contract documents.

C10 – Removal of Systems

This section only applies to the Milner, Ongley and Patworth Halls of Residence.

All existing lighting and small power circuits, distribution boards and sub-mains within the works area shall be completely removed back to the nearest live source (even if this is outside the project area) including all outlets and luminaires. Cable trunking and dado trunking shall also be taken down with the exception of that containing wiring serving adjacent areas not within the work space which shall remain.

All comms and data wiring from the area patch panels, RJ45 outlets and wifi hubs within the works area will be removed.

All useful material and equipment such as outlets, luminaires, wifi hubs, door access systems and undamaged Dado trunking will be offered back to the college for use as spares.

Care will be taken by the contractor to remove only that wiring that is necessary and to avoid damaging other wiring that is being retained.

Prior to the strip out the smoke detector heads shall be removed by the colleges nominated sub-contractor in the works area and set aside for reuse later in the project.

Prior to the strip out the CCTV and Access Control devices shall be removed by the colleges nominated sub-contractor in the works area and set aside for reuse later in the project.

C14 – Building Services Survey

The contractor shall allow for all survey costs within the tender necessary to familiarise themselves with the operation of all M&E systems serving the project area, to include the infrastructure serving these systems that is located outside the project area. The contractor is to familiarise themselves with all points of isolation to ensure quick response if any problems arise with any of the M&E systems. These surveys should facilitate the strip out works identified in Sections C10 and C90 of this specification.

C90 – Alterations/Spot Items

The contractor shall allow for all isolations required to facilitate this work and care and attention shall be given to communication with the site management team.

C20 - Demolition

All systems made redundant by these works shall be completely removed leaving no redundant equipment, wiring, pipework, support systems etc. No dead legs shall be left in any electrical systems.

Materials & Workmanship Specification

Y1 Introduction

This General Electrical Specification document defines the minimum technical requirement and quality of workmanship required to meet the high standards of installation required to successfully meet contractual requirements and client expectations.

This document shall be read in conjunction with all other parts of the engineer's design and contractual documentation, including drawings and specifications complete with site specific Scope of Works in part 2 of this document.

The Contractor (meaning electrical contractor) shall be wholly responsible for the supply, off-loading, temporary storage, unpacking, installation, installation coordination, cabling, termination, testing and pre-commissioning of all electrical equipment and materials included within the installation, as defined by the design package and accompanying contractual documentation.

The Contractor shall provide all necessary materials such as, cables, cable containment/ supports, steelwork & support frames, brackets, glands and all other materials and equipment necessary to complete the electrical installation in every way, in accordance with the design package and/or contractual documentation.

The Contractor shall provide suitably trained/qualified labour to meet the high standards of electrical installation workmanship required to meet specifications and fulfil contractual obligations. For the purposes of this document the term "Electrical engineer", shall mean the Electrical Engineer or appointed consulting engineer appointed by the client with the authority under the terms of the contract to supervise the works. Site management is deemed to mean the site construction management team.

Y2 Design and installation Standards

Y2.1 General

Design, specification, installation/fabrication, testing and pre-commissioning of all electrical systems and equipment shall comply with all relevant British and European harmonised Standards (including all current amendments), European directives and Client specific standards, current at the time of Contract placement.

All installation works shall be in accordance with the Health and Safety at Work Act, Electricity at Work Regulations, CDM Regulations, COSHH Regulations, CIBSE recommendations, Loss Prevention Council recommendations, Local Building Regulations, client engineering standards and site codes and working practices.

In the event of a conflict existing between the requirements of this standard and other accompanying tender documentation, the Contractor shall immediately bring this to the attention of the clients Electrical Engineer for clarification and further instruction(s).
All electrical equipment, installation and testing shall comply fully with BS 7671.

Y2.2 Installation Codes and Standards

Equipment and installations shall comply with the latest relevant British standards relevant including any amendments issued. Listed below are primary general standards and guides. This does not preclude the inclusion of other standards and guides relevant the electrical services installation.

- BS 7671 Requirements for Electrical Installations. IET Wiring Regulations
- BIP 2082 Electrician's Guide to the Building Regulations Part P. 2nd Edition
- BS 7430 Code of Practice for protective earthing of electrical installations
- BS 7375 Distribution of electricity on construction & demolition sites, code of practice
- BS EN 62305 All parts: latest editions. Protection against lightning. General principals
- BS EN 12464 Light & lighting. Lighting of workplaces. Indoor workplaces
- BS EN 12464 Light & lighting. Lighting of workplaces. Outdoor workplaces
- CIBSE : Lighting Guide
- BS 5266 Emergency lighting. Code of practice for the emergency escape lighting of premises
- BS 5839 Fire detection and fire alarm systems for buildings. Code of practice for system design, installation, commissioning and maintenance
- BS EN 60079 Explosive atmospheres. Equipment general requirements
- PD 6582,CENELEC R110-002 Electromagnetic compatibility (EMC). Guide to generic EMC standards.
- BS EN 61557. Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC Equipment for testing, measuring or monitoring of protective measures. General requirements
- BS EN 60204 Safety of machinery. Electrical equipment of machines. General Requirements
- 2014/35/EU The Low Voltage Directive.
- 2014/30/EU The Electromagnetic Compatibility Directive.
- 2006/42/EC The Machinery Directive.
- 2014/34/EU (ATEX) Equipment and Protective Systems intended for use in Potentially Explosive Atmospheres Directive.
- 2002/95/EC The Restriction of Hazardous Substances (RoHS) Directive.
- 2014/68/EU (PED) The Pressure Equipment Directive.
- EN 60204 all parts: latest editions. Safety of Machinery – Electrical Equipment of Machines.
- EN 61000, EN 55011, EN 55022 all parts : latest editions where applicable (Harmonic Emissions).
- EN 55024 where applicable (Harmonic Immunity).
- BS 7430:2011 Code of Practice for Earthing.
- IEC 60364 all parts: latest editions. Electrical Installations for Buildings
- FM (Factory Mutual).
- ISA The Instrumentation, Systems, and Automation Society.
- CFR (Code of Federal Regulations), 21 CFR 210 and 211 cGMPs, and 21 CFR Part 11.
- GAMP (Good Automated Manufacturing Practices).
- CGMP (Current Good Manufacturing Practices).
- A document or statement is required from suppliers of electrical /electronic equipment to state that it complies with WEEE and RoHS regulations:
- SI No.340 Waste Management (Waste Electrical and Electronic Equipment -WEEE) Regulations
- SI No.341 of Waste Management (Restriction of certain Hazardous Substances -RoHS) Regulations
- SI No.290 Waste Management (Electrical and Electronic Equipment) Regulations

- SI No.375 Waste Management (Waste Electrical and Electronic Equipment WEEE) (Amendment) Regulations

The issues and revisions of these documents in effect on the date of the quotation shall apply.

Note: All electrical equipment and systems supplied shall conform to the appropriate EU Directives and shall carry the applicable CE Marking.

Y2.3 Hazardous Area Classification

Equipment to be installed in classified areas as specified in the documents or on the accompanying drawings shall be CENELEC certifip ed by a recognised testing authority of a CENELEC member country to the following types in accordance with relevant EN Standards for construction, testing and installation. The Supplier shall only offer explosion protected apparatus manufactured to EU directive 2014/34/EU (ATEX) and all apparatus shall be marked accordingly. Where a Supplier cannot meet this requirement it must be stated clearly in the tender bid offer. The following apparatus markings are permitted:

Zone 0 - An area in which an explosive gas atmosphere is present continuously or for long periods. (Typically Explosive atmosphere for more than 1000h/yr):

II 1 G EEx ia Zone 20 II 1 D

Zone 1 - An area in which an explosive gas atmosphere is likely to occur in normal operation. (Typically Explosive atmosphere for more than 10, but less than 1000 h/yr)

II 2 G EEx ib
II 2 G EEx d
II 2 G EEx e
II 2 G EEx q (luminaires only)
II 2 G EEx p (pressurised enclosures)
Zone 21 II 2 D

Zone 2 – An area in which an explosive gas atmosphere is not likely to occur in normal operation and, if it occurs, will only exist for a short time. (Explosive atmosphere for less than 10h/yr, but still sufficiently likely as to require controls over ignition sources.)

II 3 G EEx ib Zone 22II 3 D
II 3 G EEx d
II 3 G EEx e
II 3 G EEx q (luminaires only)
II 3 G EEx p (pressurised enclosures)

The use of equipment employing other types of protection e.g. 'm', 'n', 's', etc. is permitted only if the Clients agreement is first obtained.
Where equipment (e.g. Ex equipment) is subject to approval by a statutory body or government department, this approval must be sought and obtained by the Supplier.
No certified equipment shall be modified or installed in such a way as to render its certification invalid. Any equipment so damaged shall be replaced by the Contractor at his own cost.

Y3 General Requirements

Y3.1 General

The electrical contractor shall carry out the works as set out in the contract documentation. All works shall comply with CDM guidelines. The contractor shall be expected to fully co-ordinate with other disciplines and fully integrate with the site safety management team, keep and maintain a site health and safety file, perform risk assessments and provide comprehensive method statements.

All electrical equipment, materials, and parts used shall be new, unused, of current manufacture, of the highest quality, free from defects or imperfections. The Contractor shall be deemed to have included for all works specified within the purchaser's contractual documentation, and be fully responsible for providing a complete electrical installation which functions as a fully integrated whole, complete in every way. All defects, remedial works and snags shall be rectified in a timely manner to the client's satisfaction.

Electrical Layout drawings issued indicate general locations of equipment/devices and cable routes, unless specifically dimensioned. The Contractor shall be responsible for the coordination of the electrical installation with other site disciplines to avoid equipment clashes. The Contractor shall share common M & E support steelwork wherever possible which shall require close coordination work with Mechanical and Building contractors, to provide a practical and economical cable support system. All main and secondary cable containment routes shall be agreed with the electrical engineer prior to construction/installation.

Power distribution systems installed for the express purpose of providing temporary power for construction works shall be subject to the same standards of workmanship and wiring regulations as permanent installations, except where otherwise allowed for in the contract documents or authorised in writing by the electrical engineer.

The contractor shall be wholly responsible for confirming that all quotations from suppliers that are included within his tender fully meets the requirements of the tender documents.

Y3.2 Contractor's Scope of Work

The Contractor shall be responsible for all the works as detailed in this General Electrical Services Specification and, in particular, the following items:

- Liaise with the statutory bodies including those supplying services to the site.
- Ensure that all the equipment which is being provided is "approved" for the completion of the installation and, if not, to obtain the necessary approvals in time to suit the installation.
- To provide the builders' work fabrication and coordinated drawings for the all services and detailed wiring diagrams for all the equipment.
- Inspect all the plant, equipment and materials as delivered.
- Fixing or installing correctly all plant, equipment and materials.
- Ensure that all the associated works such as electrical wiring, connecting pipework, builders' work, etc., are properly coordinated and executed.
- Test and commission the complete installation, including adjusting and balancing, as necessary.
- Demonstrate that the equipment is capable of the performance and method of operation as specified to the satisfaction and acceptance of the ECW.
- Provide samples, where requested, of all the materials which are exposed to the view in the finished works for comment.

- Demonstrate that the overall and completed systems perform correctly in the required manner and as intended by the Specification to the satisfaction and acceptance of the ECW.
- Provide record drawings for the completed installation.
- Provide Operating Instructions and Maintenance Manuals for the completed installations.
- Provide a full set of test results in an approved format for all the testing, commissioning and balancing operations.
- Provide training to the client's staff as required.

The Contractor shall refer to section 2 of this specification for more specific and particular requirements and responsibilities.

Y3.3 Working Practice

All Contractors shall adhere to the site 'permit to work' system, no work can proceed without a site work permit.

All Contractors shall receive a site safety induction, prior to entering site. All site rules and regulations shall be followed.

Contractors shall provide suitable PPE for their staff, which shall be worn at all times. High Visibility clothing shall be worn at all times.

Prior to work commencement, all Contractors shall submit satisfactory Method statement(s) and Risk Assessment(s) documentation for approval by site Health & Safety management.

All service Isolations shall be conducted by approved site staff only, after consultation with the appointed electrical engineer, and permit issuer. Isolated services and/or equipment shall be locked off, and fitted with appropriate warning notices which shall explain the reason for isolation.
All Contractors must cease work if requested to do so by the site management.

All tools used shall be in good working order, well maintained and fit for purpose. All electrical tools shall not exceed 110VAC and be supplied by a 110V centre tapped isolation transformer. All electrical equipment shall be tested/inspected for safety and be free from damage and fit for purpose. Any tools and equipment damaged or deemed not fit for use or purpose by site management shall be removed from site immediately without question. Equipment cables shall be damage free and be tagged indicating when last inspected. Repaired or jointed electrical cables shall not be acceptable. Where possible temporary construction works cables shall be kept at high level (cable tied to steelwork or on J hooks/temporary cable tray) away from the floor work area to avoid trip hazards where practicable.

Trailing cables and discarded /unused tooling and materials must not constitute a tripping hazard and shall be stowed in a tidy manner.

Hot works is defined as any work that gives rise to a potential fire risk. This includes welding, brazing, burning and grinding. Hot works requires a specific 'hot works permit', and shall be subject to site regulations and approvals.

All scaffolds shall be erected in accordance with BS 5973 or similar local recognised standard. Scaffolds shall be subject to inspection by an appointed approved person and shall receive a staff tag to signify that scaffolding is safe and fit for purpose.

Contractors shall be encouraged to maintain good house-keeping. Contractors shall be expected to remove their own waste and keep their working area clean and tidy so as to reduce the potential for accidents and injuries. Waste shall be stored in the various skips for general waste, hazardous waste or for recycling.

Contractors are responsible for providing suitable safety barriers, warning notices and cordons and welding screens required to isolate/fence off working areas to prevent accidental access by other site staff. Contractors must keep within their designated working area. Trespass into other areas is not permitted.

Contractors are responsible for providing all tools and equipment required to complete work activities which includes access equipment necessary to complete work activities which include, portable scaffolds, scissor lifts, cranes, ladders and steps. All equipment shall be in good working order. The operators of all mobile platforms shall possess an appropriate current operator's license. Contractors shall be responsible to provide their own low voltage task lighting (110V), which shall be in good working order, and fit for purpose.

Welfare facilities which include toilet and canteen facilities are provided as outlined in the attached contract documents. Additional welfare facilities may be provided by the Contractor, at their expense, which must be arranged with the site management team.
Smoking is not permitted on site.

Food consumption is only permitted in designated areas under designated times in accordance with site rules.

Site management reserve the right to monitor all Contractors work for: accuracy, conformance, quality and safety. The Contractor shall cease all work operations if so instructed by site management.

Contractors shall only stow equipment and materials in specifically approved designated areas.

Y3.4 Material Handling

The Contractor shall arrange with Site Management, a suitable site storage arrangement/facility for stowing all installation materials, equipment and tooling. The Contractor shall suitably protect the equipment to prevent damage, distortion or deterioration due to climatic conditions during unpacking/de-crating, handling and storage. The Contractor is responsible for the insurance of all equipment and materials against loss or damage during the handling, site transit to work area and installation.

The Contractor shall be financially responsible for all electrical equipment and materials up to the point of final installation.

Site management shall be informed of all planned deliveries, to enable site to adequately plan for any possible disruptions in work or operations. The Contractor shall be responsible for any off loading and material handling works, and shall supply any lifting/handling plant required to perform this task. Method statements and Risk assessments shall be provided for lifting of large items of equipment.

Y3.5 Environmental Conditions

The equipment used in the installation and in the execution of the works shall be suitably rated to function in all possible environmental conditions which may prevail in the area where the equipment is to be installed.

All electrical equipment installed outdoors shall be weatherproof and corrosion resistant.

Y4 Cable Installation

Y4.1 Drum Cable Management

Drummed cables shall be delivered to site with the drums resting on their flanges so that drum center hole readily accessible for easy lifting.

Drummed cables shall be similarly stored on site until required for installation, and adequately protected against prevailing weather conditions and mechanical damage.

Cables shall be retained on their respective drums as supplied by the cable supplier. If cable drum has any sign of damage then it shall be removed from site.

Protective battening on drums shall be initially removed to allow correct cable identification and when verified, it shall be immediately re-secured until the drum is required for installation.
When the ambient temperature is at or below 0°c, installation of thermoplastic insulated cables shall not be carried out, because of danger of damaging their insulation sheath.

Y4.2 Cable Management Fixing Brackets, Supports and Hangers

Primary cable containment systems are supported by common coordinated service support brackets fixed to ceilings or walls, specifically manufactured for the purpose of carrying pipework and cableways. Contractors shall utilise common service supports wherever possible. For Tendering purposes, the Contractor shall provision for all cable containment bracketry. Where the electrical cable route is the primary element the Electrical Contractor shall provide extended cable supports to enable other vendors/contractors, where applicable, add additional cable trays. This shall be co-ordinated with the other Contractors and vendors to determine the extent of the cable support infrastructure. Note that in some instances spare cable tray space may be provided on the Electrical Contractors trays and racks to facilitate vendor cabling, this will be indicated in the particular electrical specification.

When shared service supports are not available preferred methods are hanging supports and angle brackets. A wide variety of proprietary support brackets, clamps and fixings are readily available.
All containment systems in escape routes and associated support systems shall be such that they will not be liable to premature collapse in the event of a fire. In exceptional cases where non-metallic containment is used, a suitable fire-resistant means of support/retention must be provided to prevent cables falling out in the event of a fire.

Brackets and hanger support systems shall be chosen to support the total width span of the cable support system and be rated to carry at least twice the point load. The electrical engineer shall be consulted prior to installation of cable supports, relating to point loads on purlins and steelwork to determine if additional secondary steel supports may be required.

Special care shall be taken regarding bracket spacing's and spanning distances, manufacturer's installation guidelines shall be explicitly followed.

Welding or drilling brackets on to vessels, tanks or primary steelwork is not permitted.

Welding or drilling brackets to secondary steelwork may be permitted with prior written permission of the structural engineer.

Acceptable fixing methods to building structures are as follows:

- In hollow masonry, plaster, or gypsum board partitions / walls use rawlplug interest ® plasterboard fixing bolts, spring toggle bolts or other proprietary manufactured fixings.
- Expansion anchors or preset inserts shall be used in solid masonry walls applications.
- Self-drilling anchors or expansion anchors shall be used on concrete surfaces.
- Sheet metal screws shall be used in sheet metal studding applications
- Wood screws to be used in fixing to wood construction.
- It is forbidden to fix to pipework, pipe-clamps, ductwork, mechanical equipment, tanks or vessels, conduits, and any other equipment that may be subject to service or maintenance.
- The use of non-intrusive fixing methods such as clamps, hooks and clips is encouraged.
- Do not use powder-actuated anchors without written permission from the electrical engineer.
- Do not drill or weld structural steel members without written permission from the electrical engineer.
- Unistrut wall mounted frames or battens are the preferred method of securing wall mounted panels, devices and equipment. Ensure a minimum wall clearance gap of 30mm (minimum) for equipment mounted using this method.
- Securely anchored free standing Unistrut frames are the preferred method for supporting equipment in open areas. Large floor standing electrical boards and panels shall be installed on proprietary made 200mm plinths fitted with adjustable levelling feet or directly secured to the floor using anchor bolts (application dependant) additional wall stabilising brackets shall be used if practicable to prevent forward motion if practicable.

Y4.3 Cable Support Systems – Ladders, Tray and basket

Cable basket, Trays and ladders also known as cable containment, shall be of mild steel, hot dipped galvanised construction (unless indicated otherwise in the scope of works), purchased from a leading manufacturer and comply with BS EN 61537:2007. Only manufacturer's proprietary accessories tees and bends shall be used, site fabricated systems/components are not acceptable. Only heavy-duty support systems shall be used, unless specified otherwise.

The engineer’s specified manufacturer for cable support systems shall be used; deviation from this shall require written approval.

Cable containment systems shall be continuous, installed to manufacturer’s instructions, robustly supported with the correct support spacing. Each cable shall be fully supported along its total length. Cable routes shall be installed as indicated on the engineers’ drawings.

Supports for cable containment shall be provided in accordance with the manufacturer's recommended loading and span distances, these distances to be verified by the Contractor and confirmed in writing if requested.

Cables shall be secured to the support by means of fixings, previously reviewed and agreed by the architect, at adequate centres.

Cable fixings to structural steelwork shall preferably be by means of clamps. This form of cable support is only permitted with prior approval from the electrical engineer.

Burrs and sharp edges formed on cable containment when cut shall be removed, to the extent that the exposed edge will not cause damage to cables or cause injury to personnel.

The routes of primary cable containment shall be as shown in the contract documents. Cable containment below 21500mm with or for drops to equipment are to be agreed on site with the electrical engineer.

All primary and secondary cable containment routes are to be agreed by the electrical engineer (main runs and drops) prior to installation. Other disciplines shall also be consulted to provide a fully coordinated installation, and avoid potential clashes.

Cable tray shall be cut along a line of plain metal and not through a line of perforations. During the installation of containment all burs and sharp edges shall be completely removed. Steelwork exposed through cutting or scraping shall be painted immediately using galvanised paint, supplied by the manufacturer, following manufacturer's instructions.

During the installation of containment the cut ends shall be treated with a compatible finish to the original. Such treatment shall be to the manufacturer's recommendations and shall be carried out immediately following the cutting operation whilst the cut is clean, otherwise the cut end shall be thoroughly cleaned prior to treatment.

Where site fabrication is carried out it shall be to the satisfaction of the electrical engineer, failing which, the defective part shall be replaced at the discretion of the electrical engineer.
The electrical engineer reserves the right to inspect all works, any damaged, defective or sub-standard installation works shall be repaired and made good as instructed by the electrical engineer, without delay.

Containment support shall be robust and rigid enough to adequately support the runs throughout their entire length. Supports shall be secured to main building structure using bolts, welds or clamps previously reviewed and agreed by the electrical engineer. Clamp fixings shall be used when securing to building support steelwork like girders and purling.

Consideration shall also be given to the additional loadings imposed by personnel and access ladders during installation.

The spacing between adjacent layers of support systems shall permit ready access during the initial laying of cables and for subsequent inspection or repair with a minimum of 300mm between the bottom and top faces of the tray or rack side rails.

A minimum of 30% spare capacity (width) shall be required to cater for any future works. Spare capacity figures shall be checked with the engineers prior to installation.

All bolts, nuts and washers shall be in cadmium plated steel unless otherwise specified.

Containment (including supports) shall be installed in horizontal and vertical planes, runs being normal to surrounding building surfaces, shall be square and align with other main building support structures.

Every effort shall be made to keep all cable runs in accessible positions. The minimum height of cable supports crossing structure walkways or other minor access ways shall be 2200mm. Electrical and mechanical continuity shall be maintained throughout the length of the cable containment. Electrical continuity shall be ensured by green/yellow coloured LSF insulated cable loops, solid metallic bridges of the same finish as the containment, or flexible braided straps across joints. They shall be connected to the protective conductor of the installation and the resistance of the tray to earth measured at any point in the system shall not exceed 0.5 ohms.

Holes cut in cable trays for the passage of cables shall be free from sharp edges and burs, painted, provided with grommets, grommet strip, bushed or lined in an agreed manner by the electrical engineer.

Where cables containment pass through walls and/or roof openings with shared services, a specialist Contractor shall be employed for sealing major cable openings to prevent the passage of fire or hazardous gases from one area to another. It is the electrical contractor's responsibility to liaise with the Electrical Engineer, civil/structural Contractor and fire sealing Contractor, if appointed, to ensure all electrical openings are sealed following installation. Proprietary cable transits shall be used for cable openings containing electrical services cables only.

Y4.4 Conduit

Only leading brands of conduits shall be used and shall comply with relevant BS/EN standards specifically BS EN 61386. Only rigid galvanised steel conduits shall be used for surface and suspended installations, EMT conduit shall only be used in wall chases or in hidden wall voids/partitions unless otherwise agreed with the engineers in writing. Only manufacturer's proprietary accessories shall be used. If not specified, the clients preferred manufacturer, construction type and finish shall be used, verified in writing, prior to purchase and installation.

The minimum size conduit permitted shall be 20mm diameter. Size and number of cables in any conduit shall not exceed the maximum as specified in the BSEN 7671.

Prior to installation, all conduits ends shall be reamed, conduits thoroughly cleaned (including accessories), and flushed clean of debris. Openings and boxes shall be plugged to keep conduits clean during construction.

All conduit shall be installed true and plumb, wood or steel templates shall be installed where required. Conduits shall be aligned with other building structures and infrastructure and shall be adequately supported at regular intervals following manufacturer’s instructions. Coordinate all works with other disciplines prior to installation, to avoid potential clashes.

Rigid high impact pvc conduit shall not be used unless agreed in writing by the electrical engineer. All 90° bends shall be accurately made using a manufactured former which does not distort the tube section wall. Only one 90° bend per length of conduit is allowed. Conduit shall only be cut and threaded using a purpose made conduit machine which shall be in good working order, cutting compound shall be used.

A suitably sized pipe wrench shall be used during assembly to ensure that tube ends are fully engaged, exposed threads are kept to a minimum, to ensure rigid construction. Any Surface damage during construction shall be made good with zinc rich, or other appropriate paint finishes.

Protect work from accidental damage during construction. Any damaged components shall be replaced immediately. The total support system shall be inspected for, quality, alignment, damage, sharp edges, adequate support and rigidity, to ensure the conduit system is complete and fit for purpose, before cable installation.

Conduit termination at panels, equipment and junction boxes, shall be aligned and installed true and plumb. These requirements shall also apply to all steel supports for mounting of electrical equipment.

Where conduit connections are made to equipment not having threaded entries the area immediately around the entry shall be cleaned free of paint to ensure good metal contact with a low resistance. The conduit shall be secured using a bushing and socket to ensure smooth cable entry without loss of bore.

All conduits shall be provided with draw wires. Conduit systems shall be so arranged that it is possible to successfully draw out a cable and replace it. Runs of conduit shall not include more than one 90° bend between pull through positions.

All units such as terminal boxes, draw through boxes, inspection elbows etc. shall be positioned so they are readily accessible.

Conduits passing through the building structure walls, floors, etc. shall be sleeved. The remaining hole shall be sealed and made good with a flexible fire rated compound. Conduits passing through high to low temperature areas shall be internally plugged to prevent passage of internal condensation.

Surface run conduits shall be secured using spacer bar saddles fixed at intervals to the manufacturer's recommendations. Propriety expansion couples shall be used where conduits pass over building expansion joints.

Externally run conduit box lids shall be fitted with a gasket lid, and supported by saddles which clamp to conduit on each side of the conduit box.

Cable entries on external fittings and accessories shall be from below, where possible.
Conduit systems shall be provided with a means of drainage where internal moisture accumulation may be likely, drainage points shall be installed at the lowest point of the installation. All unused entries, temporary or permanent, shall be sealed by screwed blanking plugs.

Flexible conduit (such as Kopex) shall be used as a final connection method to vibrating or moving equipment. The rigid conduit systems shall terminate locally and continue to the appliance in a flexible conduit of pvc sheathed steel, or flexible armoured cable. All flexible conduits shall incorporate an externally connected earth wire of adequate cross section, the connections being readily visible for inspection. Flexible cable shall incorporate an integral earthing conductor as one of the cable cores.

All conduit systems shall be electrically bonded to earth via the earth terminals provided within each conduit through/terminal boxes. A 4mm earth bonding wire is sufficient.

Cables used for power and lighting circuits run in conduit systems shall be single core, insulated only, 450/750v grade, unless specified otherwise. Cables used for other services, shall have a voltage grade compatible with the system voltage.

Where conduits are buried in the building fabric, a cover shall be fitted, sufficient to prevent spalling and crumbling.

During the course of installation works, all apertures and openings on sunk conduit work shall be temporarily plugged and covered, to prevent building debris ingress.

Conduits installed in concrete floors, concrete walls and slabs shall be fully inspected by the electrical engineer/civil engineer before any concrete pouring commences. Open ends of buried conduits shall be plugged and covered, to prevent building debris ingress.
Sunken conduit work shall follow vertical and horizontal lines to the connected accessory wherever possible, and not run at random angles.

The electrical engineer reserves the right to inspect all works, any damaged, defective or sub-standard installation works shall be repaired and made good as instructed by the electrical engineer, without delay.

Y4.5 Trunking

Trunking shall comply with the relevant BS/EN standards specifically BS EN 50085. Trunking shall be of heavy gauge galvanised steel construction fitted with overlapping, turned up edge lids. The trunking body shall be provided with turned in edges for rigidity. Only manufacturer's proprietary accessories shall be used.

Only the specified trunking shall be used during construction. The specification of the trunking shall be verified in writing by the engineers prior to purchase and installation.
Trunking systems shall be installed square and true, aligned with other building structures and infrastructure, adequately supported at regular intervals following manufacturer’s instructions. Coordinate all works with other disciplines and electrical engineer prior to installation, to avoid potential clashes.

All burs, sharp edges shall be completely removed and steelwork exposed through cutting or scraping shall be painted and made good immediately after using the recommended manufacturers zinc paint, supplied by the manufacturer, following manufacturer’s instructions. Trunking and conduit systems shall be fully assembled and installed wrench tight before cable installation commences.

All units such as terminal boxes, draw through boxes etc., positioned above false ceilings shall be fully accessible.

Protect work from accidental damage during construction. Any damaged components shall be replaced immediately. Once constructed, support system shall be inspected for quality, alignment, damage, sharp edges, adequate support and rigidity, to ensure the trunking system is complete and fit for purpose, before cable installation.

Conduit/trunking termination shall be aligned and installed true and plumb. All conduit terminations shall be made off using a proprietary bush and locknut.

Bonding links for earth continuity shall be installed between adjacent lengths and joints.
Where segregation of circuits is necessary, a compartmented trunking shall be installed and identified using labels.

Trunking shall be installed in "lid up" or "lid on side" modes for horizontal runs, having due regard to the number of cables carried therein.

Trunking shall incorporate fire barriers or seals to preserve the integrity of the slabs between floor levels on vertical runs and at fire walls for horizontal runs. Means shall be provided for adequate cable support on long vertical runs of trunking.

Propriety expansion couples shall be used where containment pass over building expansion joints.
All unused entries, temporary or permanent, shall be sealed by screwed stopping plugs.
Cables used for power and lighting circuits run in trunking and conduit systems shall be single core, insulated only, 450/750v grade, unless specified otherwise. Cables used for other services, run in trunking and conduit shall have a voltage grade compatible with the system voltage.

The electrical engineer reserves the right to inspect all works, any damaged, defective or sub-standard installation works shall be repaired and made good as instructed by the electrical engineer, without delay.

Control cables shall be arranged no more than 3 layers deep, and power cables shall be in laid no more than one layer deep, except where specified in the Scope of Works Document.
Generally, cables should not occupy more than 55% of the trunking.

Y4.6 Cables

Cables shall be secured to the support by means of fixings, previously reviewed and agreed by the electrical engineer, at adequate centres.

Where cables are secured to the underside (where approved by the electrical engineer) of horizontally positioned tray-work, and on edge mounted or vertical traywork, the cables shall be secured with metallic fixings straps or cleats.

The cable fixing straps shall contain an internal metallic strip and be x-ray detectable.
Heavy duty cable ties shall be used to secure all steel wire armoured (SWA) cables to both horizontal and vertical mounted cable ladder/tray support. Use only UV stabilised cable ties for outdoor installations. In pharmaceutical, dairy and food industry applications the Contractor shall use stainless steel cable ties or cable ties with integral magnetic strip so that they can be detected by a magnetic detector. Refer to the scope of works specification for specific details where this applies.
Data cables shall be loomed using cable ties with Velcro fasteners or as specified in the scope of works.

Single core steel wire armoured cables shall not be used unless agreed with the client's electrical engineer in writing or specified in the scope of works or drawings.

The use of un-armoured single core power cables is restricted to specific applications and shall only be used with agreement from electrical engineer in writing.

Where single core power cables are to be run on ladders in vertical and horizontal runs they shall be laid in trefoil groups, fixed to the ladder using heavy duty cable cleats or steel banding. Cable ties shall not be accepted in this application.

Where single core power cables are to be installed from transformer low voltage terminals to main switchboards and cannot be laid in trefoil configuration, they shall be installed in a flat formation, spaced and individually cleated using non-metallic cable cleats with no two cables of the same phase adjacent one another. Special care shall be taken to ensure that spacing and phase positioning is maintained leading to and within switchgear termination chambers.

Cables shall be suitable for the environment in which they are installed, such as clean, corrosive or damp environments. The Contractor shall ensure that the cables sheath is suitable for the process and the environment in which it is installed and that there are no detrimental effects to the cable sheath due to adverse environmental conditions or sunlight.

Cables installed between variable frequency drives and motors shall be Olflex Servo 700 CY type suitably shielded cables to eliminate any adverse EMI.

Where cables are laid on ladders, cable ties and cleats/clamps shall be used at intervals in accordance with BS7671 requirements for electrical installations.

Cable joints are not allowed unless agreed with the electrical engineer in writing. This requirement does not apply to earthing systems utilising thermoweld or similar junctions.

Cables shall be installed in neat, straight runs having due regard to plant and structure movement which may result from thermal expansion, mechanical operation, vibration and settlement.
Cable conductors shall not be subjected to undue pressure or sharp bending during termination.
SWA cable conductors shall be fitted with single-indent crimp-type terminal lugs as recommended by the cable manufacturers.

Control cables shall be arranged no more than three layers deep and power cables shall be no more than one layer deep.

Fine wire stranded flexible cable cores such as SY or CY up to 4 mm2 c/s/a shall be terminated with the use of hexagonal crimp-type lugs or four-sided crimp boot lace ferrules.

All cable lugs shall be supplied and installed strictly in accordance with the manufacturer's instructions, using the manufacturer's recommended crimping dies and compression tools. All crimping tools shall be visually inspected and tested each day before use.

All cable routes shall be accurately measured and cable length verified prior to cutting any cables. The Contractor shall install all cables as detailed in the cable schedule provided. Cables shall generally follow the routes detailed in the contract documentation and indicated on drawings provided. Changes or deviations to these routes shall be agreed with the electrical engineer prior to installation, and drawings marked up to enable 'as built' drawings to be produced.

Where cables leave the support system they shall do so in a manner which does not cause damage to the cable and they shall be adequately supported along their entire route.

All cables shall be left clear of service pipes. There shall be a minimum distance of 400mm between any cables and the lagging of hot lines (e.g. Steam).

Where cables pass vertically through floors, walkways, etc., protection against mechanical damage shall be provided as detailed on the contract documents or by installing them in individual lengths of pipe set in the floor and extending at least 1250mm above floor level.

Access holes for cables passing through solid floors or walls must be fire sealed using an approved method agreed by the electrical engineer.

The minimum bending radius of any cable shall be based on the manufacturer's recommendations but not less that the BS 7671.

Where cable ends are coiled pending installation, the cables shall be coiled individually. The coils of each individual cable shall be strapped together firmly using adhesive tape or twine to avoid tangling. Wire shall not be used for this purpose. All cable ends shall be sealed to prevent the ingress of moisture. Coiled cables shall be protected to prevent damage.

Each cable coil shall be clearly identified in a legible manner using non-corroding material. Coils shall be arranged in sequence and for ease of accessibility or installation.

Note: any cracking, splitting or mechanical damage to the insulation sheath of cables shall be brought to the attention of the electrical engineer immediately. Cables shall be handled and installed in a manner which does not cause damage by abrasion or by excessive tension. The pulling methods to be used shall be to the satisfaction of the electrical engineer.

Cables shall be laid in uniformed parallel formation. Twists, kinks, crossing or intertwining of cables is not acceptable.

Cables installed on horizontal runs shall be strapped at intervals of 1000mm, at each bend or change in direction and not more than 600mm from a transit or gland position. For vertical runs, temporary cable ties may be utilised prior to the installation of permanent clamps/ties.

Cables larger than 20mm outside diameter shall be clamped individually but cables of 20mm diameter and smaller may be strapped together so that cables are laid no more than one deep. Holding down straps, clamps or tie wraps shall be of non-corrosive material compatible with the cable sheath and support steelwork and be of such dimensions that when tensioned for the final installation they do not damage the cable sheath or substructure.

On vertical and (vertical face) horizontal runs, cables shall be strapped to the ladder or tray at minimum 500mm intervals or at the nearest lower run spacing to this.

All cables shall be so supported that no strain is placed upon the cable, cable gland or equipment.

Y4.7 Cables Installed Below Ground Level

Installation of direct buried cables shall not commence until the entire cable route survey and excavation is complete, cleared from stones and debris, inspected and deemed fit for purpose. Once cables have been laid, before backfill, each cable shall be tested.

Cables installed direct buried underground shall be surrounded by not less than 150mm of washed sand (compacted) with continuous concrete or earthenware cable cover layer above. Selected backfill shall be free from large stone and other injurious objects (compacted) and continuous marker warning tape ('DANGER ELECTRICITY CABLE BELOW') shall be installed along the complete route length to indicate presence of electric cables. High Voltage cables shall also have a similar warning tape, except indicating High Voltage with voltage reference e.g. 11,000 Volts. Where indicated within the particular specification, the Electrical Contractor shall install red warning concrete proprietary cable tiles over HV cabling located underground to provide some mechanical protection of the cable.

The minimum depth of cover from the cable to the finished grade shall be in accordance with the requirements of the BS7671 standard or as set out on the drawing details forming part of the contract documents.

Where it is necessary to route cables under roads, hard standing or civil constructions which dictate the use of ducts, cables shall be protected by concrete encased ducts. Cement, steel or heavy duty pvc pipes of adequate cross-section shall be used. Bitumen bonded fibre types are not acceptable. Cable ducts shall be sealed at both ends using materials which are not soluble and are resistant to any likely corrosive, verminous or insect attack in the area concerned. 20% spare ducts complete with spare draw ropes shall be provided and all unused ducts shall be similarly sealed. Sealing method and materials shall be agreed with the electrical engineer. Where steel pipe is permitted, the pipework shall be internally smooth and treated with an anti-corrosion finish. A lead collar shall be fitted at the ends of steel pipes.

Where cables enter the building perimeter wall, suitable proprietary manufacture (subject to the approval of the electrical engineer) cable transits shall also be utilised in order to neatly manage the cables and ducting entries. All cable entries into building structures or man-hole chambers shall be water tight.

All cable ducts shall be rodded to proven free from obstructions, Large diameter heavy cables shall be installed using a cable winch and tensioning device, and specially constructed rollers. Smaller cables of up to 25sqmm can be laid by hand.

Underground cable routes shall be identified by surface cable marker posts. Marker posts shall be spaced at 20m intervals, and placed at turning points.

Accurate and detailed records including dimensions from other structures/services of all buried cable locations are to be kept by the Contractor for issue to the electrical engineer and for inclusion in the O & M manuals.

Draw wires shall be installed in all spare ducts.

Underground ducts shall be filled in sequence from bottom to top and left to right.

Cable chamber covers shall be tagged and the cable chamber shall be fitted with suitable supports for the cables and shall have provisions so as to prevent the cable chamber cover from falling in and damaging the cables.

Y4.8 Cable Markings

Cables shall be identified by their respective numbers as indicated in the contract documents. Any cable not listed with a specific cable tag shall be marked using the appropriate sub-circuit reference. All cables shall be identified by permanently secured markers fixed at each end of the cable, and on both sides of intermediate cable transits, ducts or apertures. All markers shall be so positioned that each cable number is readily identifiable without separating the cable groups or harnesses.
Cable markers shall be of non-deteriorating materials with indelible legends. Cable markers shall be clearly visible from the direction in which the cables would be normally inspected. In certain applications stainless engraved cable markers shall be required, refer to the scope of works specification.

All underground cables shall be identified at entry/exit points within ducts, Cable chambers, trenches and buildings. Core identification, shall be provided for all power and control circuit cables by means of colour coded, numbered or lettered ferrules. All ferrules shall be positioned so that they are easily readable.

Y4.9 Cable Terminations

Under no circumstance shall cables pending field connection be terminated on to a “live “ energy source such as a panel-board. The termination order shall always be: Install, label & dress, Test, field Terminate, source end terminate, re-test.

All armoured cables shall be terminated using brass double seal compression glands with earth tag, complying with the relevant BS 6121.

Cable gland types and sizes shall be as specified in the contract documents and where required, certified for installation within a designated hazardous area zone, incorporating both inner and outer compression seal rings and armour clamp.

All conductors shall be terminated with compression type lugs, applied by means of appropriate compression tools, unless the equipment being connected to is equipped with clamp type terminals. The correct size of lug and crimping tool shall be used in accordance with manufacturers recommendations to ensure good conduction properties and mechanical strength.

All cable glands shall be fitted with close fitting shrouds. Stress relief of terminations for high or medium voltage cables shall be carried out in accordance with the cable manufacturer's recommendations and standard installation drawings. Cable entry shall be on the underside of apparatus unless this is not possible due to equipment arrangement or space limitations.
All unused cable entries in apparatus shall be sealed by the use of the appropriate type of screwed plug.

Y4.10 Segregation of Services

Cables of various voltages, functions and separate supply sources, shall be segregated from each other and spaced sufficiently far apart to eliminate interference between services, subject to the minimum distances indicated below:

	Control and Data	Communications	Small power	Power (LV)	Power (HV)
Control and Data	**0**	**100**	**100**	**300**	**1000**
Communications	**100**	**0**	**100**	**300**	**1000**
Small Power	**100**	**100**	**0**	**300**	**1000**
Power (LV)	**300**	**300**	**300**	**0**	**300**
Power (HV)	**1000**	**1000**	**1000**	**300**	**0**

Circuits for emergency services and those for services other than emergency services shall be physically separated in accordance with BS 7671.

The minimum distance between antenna co-axial cables and M.V. cables shall be 3000mm.

Y5 Earthing

Y5.1 Objective

The objective of earthing and bonding shall be to provide the following: -

- Safety to Personnel.
- Protection against static.
- Protection for external services.
- Protection within hazardous areas
- Protection against earth leakage currents.

Y5.2 Earth Network - General

An Earth Network shall be installed as detailed on the relevant layout drawings and schematic.
The Contractor shall supply and install a complete earthing system to effectively and safely earth all extraneous metal work with possible contact to electricity, other metallic services such as pipework and ductwork, electrical equipment and plant including metallic cable sheaths, cable support systems, lighting fittings, switches and socket outlets within the building as set out in BS7671.
All non-current carrying metal parts of electrical equipment shall be effectively bonded to the earth network.

The main earth network shall consist of a main cable loop or loops to individual earth bars.
The earth network within each of the buildings shall be bonded to the structural steel where shown on the drawings. This bond shall consist of sheathed copper earth cable, bolted to the steel columns at one end, and the earth bar at the other.

Y5.3 Installing Cables

The protective conductors shall be installed on the same trays/ ladder rack and in ducts as the power cables.

Protective conductors shall be laid directly in the ground where cable ducts are not available.

Protective conductors run underground shall be laid without breaks or joints but when these are unavoidable underground joints shall be brazed or brought above ground and attached to a copper earthing bar with crimped lug connectors.

Protective conductors run above ground shall be strapped to the main power cables they are associated with using cable ties.

Every earthing connection after completion shall be liberally smeared with anti-corrosive paste. Every steel to copper connection shall only be made after both surfaces have been cleaned and oxide inhibiting paste applied.

Spare cores of glanded multicore cables shall be terminated and collectively earthed within the termination enclosure to prevent harmful induced voltages.

The armour of cables shall not be used as the sole protective conductor unless indicated otherwise in the scope of works. A separate single insulated, green/yellow LSZH covered copper cable tie wrapped at intervals to the main cable shall be employed, or a separate earth tape may be used. The Contractor shall record the route of the protective conductors to the earth electrodes with dimensions marked on the drawings to accurately define the position of the runs. The earthing system will not be accepted as complete until the record information has been provided to the satisfaction of the Engineer.

Protective conductors shall be LSZH covered green/yellow.

Y5.4 Earth Electrodes

Earth Electrodes where specified in the scope of works shall be hard drawn copper rods.
In areas where the ground structure is rocky, holes shall be drilled and backfilled with a moisture retaining clay containing calcium sulphate before the rods are driven.

Electrodes shall be driven into the ground with power tools in 1200mm sections.
Hardened steel tips and hardened steel driving caps shall be fitted before the rod is driven into the ground and when each 1200mm section has been driven the driving cap shall be removed and fitted to the next section. The sections shall be connected by means of the special coupling screws supplied by the rod manufacturer.

Earth electrodes shall be driven vertically.

Every earth electrode shall be provided with a heavy duty inspection pit fitted flush with grade level. Where the ground proves unsuitable for the clad copper rods earth mats shall be installed comprising copper lattice mats laid in prepared ground with low resistance earthing compound provided to assist in obtaining a lower earth resistance reading.

Y5.5 Spacing of Electrodes

Where more than one electrode is required to achieve a satisfactory resistance level, additional parallel connected earth electrodes shall be installed no closer than twice the length of the longest electrode apart.

Y5.6 Earth Bars

Earth Bars shall be provided for the connection of branch earths.

Each MCC or switch room shall be provided with a main earth bar with a minimum of 50mm x 6mm of hard drawn copper bar securely fixed to the wall on insulated mountings. The main earth and all protective and bonding conductors shall be securely bonded to the main earth bar. This bar shall be adequately sized to terminate all cables, with 30% spare capacity.

The Main Earthing Conductor shall be connected to the main earth bars through a removable test link located close to the main earth bar and all cables shall have bolted crimp lug connections.

Y5.7 Earthing Branch Circuits

Earthing to individual items of equipment shall normally be provided with their own earthing branch circuit but in certain cases the branch circuit may also be looped to other items of equipment.

Where looped branched circuits are used except for the last item of equipment the earth branch circuit cable shall not be cut or broken but shall be connected to the equipment such that the removal of any items of equipment will not disconnect the earthing of other items of equipment.

Y5.8 Bonding and Static Earthing

All exposed conductive parts including structural steel, steel floors, purlins, metal cladding, pipe racks, conveyor walkways and platforms, process and mechanical equipment, ducts, pipework, cable containment and panels etc; shall be electrically continuous and securely bonded to the earthing system to form an equipotential system, including the lightning protection system.

All extraneous metal work used in construction shall be bonded to the earth network with direct conductor connections and supplementary loop bonding.

Cable ladder and cable trays shall have earth continuity maintained throughout their length with manufacturer's copper flexible straps across joints and shall be bonded to the structural steelwork. Bonding shall be installed as follows;

Equipotential Bonding		
Description	Bonding Required	Size (mm2)
Metallic services entering or leaving the building	To main earth terminal at each point of entry or exit	As BS7671
Steel reinforcement or structure	To main earth terminal or bar	As BS7671
Metal sink, basins, etc (including pipes)	To earth terminal of nearest 13A socket outlet	4
Cable tray, ladder, trunking etc entering or leaving MCC rooms.	To main earth terminal or bar	25
Cable tray, ladder, trunking etc along runs	Wherever support system is not electrically continuous	25
Metallic ductwork and pipework	To earthed frame of electrically driven equipment or plant	25
Metallic ductwork and pipework insulating joints	Across joints with copper braid bonding conductors	25
Metallic cladding over thermal insulation	To fixed metalwork forming part of the electrical installation	4
Steel floors, platforms or stairs [1]	Cross bonding to other earthed metal work as required and proved by testing	4

Equipotential Bonding		
Description	Bonding Required	Size (mm2)
[1] Unless the manufacturer provides other specific recommendations in which case these shall be observed, this bonding shall be in addition to any chance connections via luminaires and equipment.		

Y5.9 Cable Earthing

The armour of all power and control cables shall be earthed at each end with final connection to the panel/equipment earth via an earth strap from an earth tag on the gland to the earth stud. Earth straps shall be sized in accordance with the requirements of the regulations and shall be a minimum size of 2.5mm² except where otherwise indicated on the drawings. On power cables to motors a separate earth conductor shall be provided. This earth conductor shall be sized in accordance with the regulations and shall be a minimum size of 4mm².

Y6 Lighting

Y6.1 Lighting Philosophy

The aim is to provide a highly efficient, functionally practical lighting system which encourages the use of modern cost saving technologies and practices which conform to current standards and codes.

Intelligent/programmable lighting systems may be considered for some applications where practicable and commercially viable .

The lighting system employed shall be zonal. A zone may constitute a room, corridor, partial room/office/shop floor, factory floor work area or thoroughfare. Lighting Zones in large areas such as factory floors may be linked together to create larger zones, lighting patterns shall be coordinated with working practice/activity and usage. All lighting shall be controlled as specified in the scope of works particular specification.

Both lighting system concept and design shall be subject to customer approval, and site specific standards details of which shall be outlined within the 'Particular' specification. All materials and equipment chosen must be approved by the customer and verified in writing prior to purchase. The Contractor shall arrange for sample light fittings to be supplied for approvals early in the construction program to avoid delays in delivery of equipment.

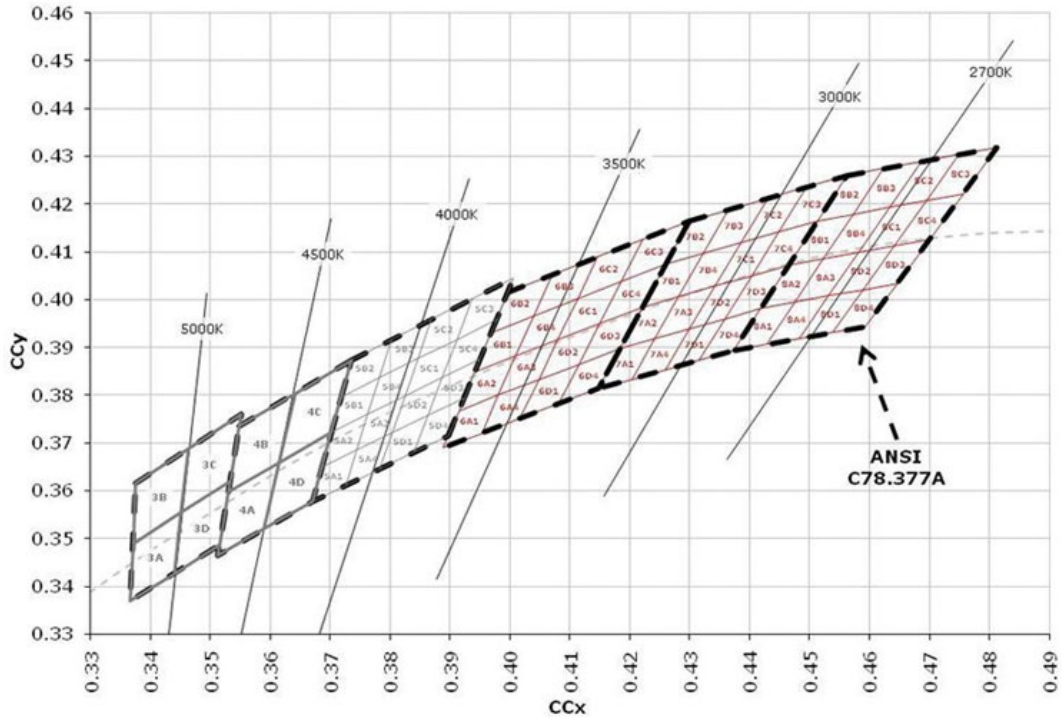
Y6.2 LED Lighting

The use of LED lighting systems shall be installed provided that fixtures and fitting meet the required installation and performance standards, demonstrate superior efficient gains (lm/Watt), compared to other technologies such as high efficiency T5 fluorescent systems.

Y6.2.1 LED binning

When using LED light fixtures it should be wise to procure luminaires from one source to ensure colour consistency of the LED fixtures is uniform. Specified luminaires should utilise tight bin quadrants around the specified colour temperature as shown within the ANSI C78 377A standard. This shall ensure that final visual aspects of the lighting installation are uniform and consistent.

LED modules utilised in specified luminaires for one area should be from no more than four quadrants within the ANSI bin as shown below:



Where financially possible four adjoining quadrants shall be specified within one area.

Y6.2.2 Manufacturers

To ensure that consistency is kept throughout the installation and that the relevant binning requirements are kept, LED modules from the following manufacturers shall be used:

- CREE
- Samsung
- Tridonic
- Philips
- Osram

Further on from this, and to aid future maintenance of LED luminaires, LED products from the Zhaga Consortium approved member list should be used.

Y6.2.3 Standards

The following standards should be adhered, but not limited to when selecting manufacturers of LED modules:

LED Standards	
ANSI C78 377A	TC2-46 CIE/ISO standards on LED intensity measurements
TC2-50 Measurement of the optical properties of LED clusters and arrays	LEDs and LED modules IEC TS 62504 Terms and Definitions for LEDs and LED modules in general lighting
TC2-58 Measurement of LED radiance and luminance	TC2-64 High speed testing methods for LEDs
BS EN 61347-2-4 :2001 (IEC 61347-2-4:2000) Lamp controlgear. Particular requirements for d.c. supplied electronic ballasts for general lighting	BS EN 61347-2-13 :2006 Lamp controlgear. Particular requirements for d.c. or a.c. supplied electronic controlgear for LED modules
ISO – International Standards Organisation	TC2-63 Optical measurement of High-Power
BS EN 62031:2008 LED Modules for general lighting. Safety Specifications	BS EN 62384 :2006 D.C. or A.C. supplied electronic control gear for LED modules. Performance requirements
BS EN 62384 :2006+A1:2009 DC or AC supplied electronic control gear for LED modules. Performance requirements	BS EN 62386-207 :2009 Digital addressable lighting interface. Particular requirements for control gear. LED modules (device type 6)

Y6.3 Internal Lighting

The lighting systems shall comply with BS EN 12464 part 1 and follow current CIBSE interior lighting guidelines. All lighting shall achieve a minimum of 55 Luminaire Lumens per circuit Watt to comply with Building Regulations Part L. However, in certain circumstances this may be relaxed to 45 luminaire lumens per circuit-watt, as specified within the particular specification.

Typical lighting levels, by default, shall comply with CIBSE recommendations, however the scope of works shall take precedence and shall outline the lighting level requirements for each individual project. The average lighting levels specified shall be calculated and measured in the horizontal plane 750mm above floor level (where worktops or workstations are generally used), however measured at floor level where applicable to plant rooms and general areas.

The client site illumination standards may apply if in excess of guidelines indicated above. These requirements shall be detailed in the particular electrical specification.

Uniformity of illumination shall be no less than 0.8 (Emin/Eav) wherever practicable. Colour rendering shall be a minimum of 80RA, reflective index (glow) shall be between 16 (offices) to 25 (production areas) application dependant, following CIBSE guidelines. Refer to the particular electrical specification for exact project specific performance requirements.

The requirements for illumination levels and uniformity values shall be derived from BS12464-1:2011 section 5.

Lux levels on all aspects of room surfaces shall be considered when finalising artificially lit environments. Within areas where face to face contact or display viewing is the main practice the illumination on the vertical plane at the viewing level shall be considered in detail.

All Lighting cables shall be clearly identified with a unique number and shall identify the source of supply for ease of isolation. All quick release fittings shall be clearly identified with a unique identification sticker identifying the source of supply. The identification shall include the lighting distribution board reference, circuit breaker way and phase i.e. LDB1-LG-R-1 (01) (Lighting Distribution Board 1, LG Lighting circuit, R phase, Circuit 1 (MCB no. if applicable)). All cable identification labels must be of a clearly legible non-corrosive type. All wires shall be ferruled with a unique wire number.

Luminaires shall be positioned and installed as indicated by detailed design drawings, to ensure that design lighting levels are achieved. Deviations from the designed lighting plan may be required. Deviations from the lighting design shall be discussed and agreed with the electrical engineer.

Drawings shall be marked up detailing all deviations/corrections and handed over for inclusion in the final 'As Built' documentation.

Where more than one phase is present in multi-gang switches, suitable phase barriers and a clearly visible warning label shall be fitted.

Wall mounted key operated emergency light test switch, shall be installed in every lighting zone to enable regular operational checks of maintained/emergency light fittings.

Lighting groups (zones) shall be wired in phase rotation in a sensible balanced load configuration. Each light fitting shall be fed by a single phase supply from local lighting boards, this includes emergency lighting feeds, which shall be fed from the same un-switched live phase. Shared neutral wires are not allowed. The neutral wire used must correspond to its respective phase conductor. All light fittings, occupancy sensors, switches and containment shall be earth bonded. Earth wires shall be distributed through each circuit to each light fitting Klik.

Unless specifically instructed, all internal luminaries shall be fitted with a flexible heat resistant lead (max length 2m), complete with quick release Klik plug.

For ease of maintenance a quick release plug and socket system shall be used. The 'Klik' system is preferred. A fixed installation socket shall be positioned less than 500mm (within easy reach) from the light fitting. The Klik socket shall be fixed to conduit rose (through) box which shall be attached to a fixed conduit system, tray or trunking above or adjacent to the light fitting. To discriminate between light fitting plug and sockets, ordinary light fittings shall be fitted with a three pin plug and emergency (maintained) fittings with a 4 pin (red) variant.

The Contractor shall ensure that the continuity of the cable armour and/or circuit protective conductor is maintained where cables loop in and out of luminaires, socket outlets and junction boxes.

The cable CSA shall be copper 2.5mm² or as specified in the particular electrical specification. 1.5mm2 CSA cable shall not be acceptable unless specifically approved by the electrical engineer in writing.

The Contractor shall supply and fit appropriate non-corrodible circuit identification labels to all luminaires, switches and sockets.

Self-contained emergency luminaires or converter packs fitted to primary luminaires shall be identified by a green led visible from below.

Lighting control systems shall be as described in the particular specification.

Y6.4 External Lighting

Lighting systems shall comply with BS EN 12464 part 2, BS 5489 and follow current CIBSE exterior lighting guidelines for vehicle roadways, pathways, access ways, building perimeter and security lighting.

Typical lighting levels, by default, shall comply with BS EN 12464-2:2014. The average lighting levels specified shall be calculated and measured in the horizontal plane at floor/ground level.

Client site illumination standards may apply if in excess of CIBSE guidelines as indicated below. Exact project specific requirements shall be detailed in the electrical scope of works specification.

Y6.4.1 Typical external lighting lux levels

External Area or Function	Lighting Level (Lux)
Site Roadways	10
Car Parks	20
External Walkways & Paths	20
External Entrance's	100
Loading Bays	100

External lighting circuits shall be switched using contactors located in the designated distribution board and controlled via externally mounted photocells or panel mounted time-clocks, as indicated on the contract drawings. All photocell switched external lighting shall be equipped with a manual override switch. External lighting systems shall be in accordance with the requirements of BS 5489 and CIBSE external lighting guide.

Photocells shall provide automatic dawn on, dusk off switching and shall be moisture, temperature and vibration-resistant with die-cast aluminium housing incorporating time delay feature to prevent false switching. The unit shall be field adjustable to control operating levels.

External lighting circuits shall generally be wired in multicore XLPESWALSZH cable. The cable size will be based on the cable lengths and the voltage drops. For external underground located cables the CSA shall be equal or in excess of 6mm² dependent on the load and the voltage drop calculations.

Each lighting column shall be fitted internally with a suitable IP65 rated fused spur to ensure that failure of one light will not cause isolation of the entire circuit.

Y6.5 Emergency Lighting

The Contractor shall supply, install, test, commission and certify a complete emergency lighting installation which shall comply with BS EN 5266 with luminous levels specified within BS EN 1838 as specified in the contract documentation and scope of works specifications.

A comprehensive system of internally self-contained maintained directional exit signage meeting the requirements of BS 5499 shall be installed as part of the emergency lighting installation in order to aid rapid evacuation. Internally self-contained maintained light fittings are the preferred system of providing emergency background lighting during power loss. Supply for the emergency luminaries shall be taken from the appropriate distribution board, the addition emergency feed wire shall be of the same phase and CSA as the light fittings main feed wire.

Either, Remote Key test points shall be located in each zone to enable regular local testing of emergency and maintained light fittings, or an addressable emergency lighting system may be specified refer to the scope of works specification.

Additional emergency lighting shall be provided to emphasis particular areas such as fire fighting equipment, evacuation routes, hazardous process equipment, changes in direction and emergency exits all of which will be identified in the particular specification documentation and drawings. Emergency lighting shall be installed at all external building entrances and exits. Additional external emergency lighting shall be installed to aid building evacuation, and aid in routing personnel to safe evacuation zones.

In some cases, especially in countries with extreme climates, a certified suitable for emergency lighting application, central emergency lighting battery system may be preferred/necessary. These systems shall be design to provide 3 hours battery backup and shall be capable of fully recharging within an 8-12 hr period. Sealed maintenance free lead acid batteries shall be specified with a minimum of 8 years life guarantee. The inverter shall have a bypass system to enable easy maintenance, and reduce down time. The central battery system shall be fitted with a central emergency battery central test facility. In this instance the emergency lighting circuits shall be wired in suitable 3 hour fire rated FP 200 cable.

Each emergency light fitting shall be wired via a local fire proof junction box.

The emergency lighting design and installation shall be fully coordinated with the building Architect and customer to define escape routes and system of emergency escape.

Y6.6 Lighting commissioning and functional tests

Once installed and electrical tests are fully completed, illumination level readings shall be taken (under night time conditions) to verify design parameters. Any adjustments shall be made at this point and occupancy sensors shall be adjusted to optimise settings. All emergency (maintained) light fittings shall be tested. Adjustments shall be made to external floodlighting to obtain maximum efficiency. All light measurement readings shall be tabulated and handed over to the electrical engineer.

The complete lighting system will be fully functional tested to ensure that each lighting system element, and mode of operation, works correctly and in accordance to design parameters.

The certification and testing of the complete emergency lighting system is the responsibility of the contractor regardless of the supply of any element of the installation being through a third party Contractor or Supplier.

Y6.7 Hazardous Area Lighting

All Hazardous area luminaries shall be wired direct using XLPE/SWA/LSZH. Atex zone 1 glands (E1FW), and Atex 'Ex de' junction boxes are required. Light fittings shall be specified with through wiring in order to limit the quantity of Atex EX rated junction boxes. All equipment shall be installed as per manufacturer's instructions and Atex conformance certification, requirement. All installation works shall require inspection by a suitably CompEx qualified Engineer. Note some Atex Luminaries may require two earth conductors.

Lighting circuit wiring in hazardous areas or special applications shall be as set out in the detailed scope of works/particular specification forming part of the contract documents.

Hazardous area switches/breakers shall be of the double pole switching type. All unused/spare multicore cables and wires shall be terminated to earth.

Y7 Socket/Small Power Outlets

Y7.1 Single Phase Socket & Spur Outlets

All socket outlets shall be installed in accordance with the manufacture instructions. Types, sizes and finish shall be as indicated in the contract documents, and in compliance with the relevant standards.

All 230V AC single phase socket outlets shall be switched, RCBO (RCD 30mA) protected. Recessed socket outlets shall be installed within public and offices environments including corridors, offices, laboratories, public common areas. Surface mounted single phase metal clad socket equipment shall be used in general service areas and blue 3 pin industrial pattern wall mounted units shall be installed in workshops and other industrial areas. All small power sockets shall be suitably IP rated to suit installed environmental conditions.

Wiring for 13A single phase socket circuits (radial) shall be minimum 4.0mm² (c/s/a) insulated copper cables unless otherwise specified and subject to calculations. Ring circuits (only as approved by the electrical engineer) shall be wired using 2.5mm² (minimum) insulated copper cables unless otherwise specified and subject to calculations.

Atex rated sockets shall be 2-pole protected from an RCBO.

UPS outlets shall be clearly identified and may be of a unique plug and colour configuration to prevent accidental use.

In some IT server room applications, UPS supplied sockets for specific use, often have no RCD protection. These shall be clearly labelled that no RCD protection is provided. Note that these sockets shall be installed in the industrial CEE form type socket arrangement either mounted under floor or overhead.

All power cables shall be clearly identified with a unique number and shall identify the source of supply for easy of isolation. All socket outlets shall be clearly identified with a unique identification sticker identifying the source of supply. The identification shall include the distribution board reference, circuit breaker way and phase e.g. DB1/2L3 (Distribution Board 1 way 2 line 3). All cable identification labels must be of a clearly legible non corrosive type.

Spur outlets shall include 20A switch, double pole fused unit and neon pilot light. Spur outlets shall have flex outlet plates where they are feeding adjacent equipment. In other cases recessed conduit from the flush box shall be run to the terminal point of the equipment being fed unless otherwise specified.

Y7.2 110V Single Phase Outlets

Where there is a requirement to install 110V AC socket outlets, the sockets shall be supplied from a centre tapped transformer. Surface mounted yellow 3 pin industrial pattern wall mounted units shall be installed as standard. Often these sockets shall be installed in workshops and other industrial areas and shall be suitably IP rated to suit installed environmental conditions. Both Primary and secondary side transformer overload, and short circuit protection shall be provided. All sockets served from the transformer requires 30mA earth leakage protection.

Y7.3 400V Three Phase Outlets

Where there is a requirement to install 400V socket outlets, surface mount red 5 pin industrial pattern wall mounted units shall be installed as standard. The preferred option wall mounted units shall be IP44 (minimum), 32A interlocked switched with integral 3 phase MCB/RCD devices. Often these sockets shall be installed in workshops and other industrial areas and shall be suitably IP rated to suit installed environmental conditions. Some applications may require the 63A variants, especially in engineering workshops.

Note: in Atex 3 phase socket applications 4-pole Neutral isolation is required from the MCB/RCBO. All three phase socket outlets shall be wired in a radial configuration.

Y8 Junction Boxes and Enclosures

All junction boxes shall be suitable for the operating environment with a minimum degree of enclosure protection of IP54 (internal locations) and IP65 (external locations). Only leading brands of junction box and wall mounted electrical termination enclosures shall be acceptable.

All junction boxes shall be manufactured from materials as specified in the particular electrical specification. The use of dissimilar metals in contact is prohibited in the construction or installation of enclosures. No aluminum or aluminum alloy is permitted. Gaskets shall be of a corrosion-proof material such as neoprene. Internal wiring shall be enclosed in slotted plastic trunking. Internal wiring shall only fill 45% of the internal cross sectional area. The use of cable ties within trunking systems is forbidden.

In line cable joints are not acceptable. In line wire connections are not acceptable. Connections made and concealed within conduit/trunking systems are not acceptable. Conduit inspection tees, elbows and enclosed sectional trunking shall not function as termination/junction boxes.

Junction boxes shall be sized to provide sufficient space for glanding and spreading cables without putting any undue strain on both cables, terminations or terminals. All hinged doors, removable gland plates and backplates shall be bonded to earth by a minimum 6mm² CSA earth conductor.

Terminals shall be “klippon” DIN rail mounted, complete with end covers and end clamps. Terminals shall be correctly sized to match wire gauge. Strip terminals and chocolate block type terminals are not acceptable. Opaque terminal covers shall protect medium voltage terminals.

All junction boxes and electrical enclosures shall be clearly identified with a screw fixed, engraved traffolyte label. All terminals shall be clearly numbered, with a unique terminal block number/designation, and individual terminal number. All earth, neutral and bonding terminals shall be clearly identified.

Cables shall be bottom entry unless specified differently. All cables shall enter via a suitable IP65 SWA gland for armoured cable or compression gland for un-armoured cables. All unused cable entries shall be sealed by means of a suitable screwed blanking plug and IP washer. All unused cores (labelled spare) shall be terminated to earth.

Intrinsically Safe ‘IS’ circuits shall have a dedicated IS junction box labelled "Contains IS Circuits". All IS teminals shall be blue, internal plastic slotted trunking shall be blue. The Junction Box shall contain only IS equipment and IS cable/wiring. IS cabling shall not be shared with any other cabling and shall be mounted on/or within a dedicated cable support system.

Signal and power cable/wiring within junction boxes shall be segregated. Internal power and instrument trunking systems shall be separate. Signal cables may cross power cables at right angles, but shall never touch and remain segregated. These restrictions may be relaxed somewhat at entry points within panels and instruments where practicable constraints exist.

Installation of field instrumentation equipment includes for transportation from storage and supply, fabrication, painting and erection of all supporting frames and brackets and the fixing of these items and housing of steelwork, process piping, pipe stands and support bracketing. The work also includes the provision and installation of all local junction boxes and the supply and installation of all impulse tubing, fittings and support bracketing.

Installation of instrument control panel includes for transportation from storage and the installation on frames and earthing of control panels, Servo Actuator Panels, marshalling Panels, Logic and Interface Rack. Includes also for the installing and connecting of instruments and meters supplied separately for reasons of safety and the mounting of marshalling boxes, measuring transducers and probes. Includes for the supply, fabrication, painting and installation of all supporting frames to meet the Client's requirements.

Y9 MCB/RCBO Distribution Boards

Distribution boards (DB) shall conform to BS-EN60436, shall be of steel gas stove enamelled powder coated construction with hinged doors and fully welded, flat, crevice free seams. IP31 rated for indoor use, IP65 for outdoor use. Indoor boards shall be suitable for wall mounting in a suitable dry area such as electrical plant rooms or electrical cupboards. Specific project board IP ratings are indicated in the scope of works.

Distribution boards shall be fitted with both top and bottom removable gland plates, each gland plate shall be sized to accommodate correctly sized IP55 (minimum) SWA cable glands for all incoming and outgoing circuit cables and spare ways. Suitably sized IP55 (minimum) compression glands may be used for any specified unshielded power cables.

Only leading brands of distribution board and associated proprietary equipment shall be used. Schneider Acti 9 boards (indoor use) and MCB and RCBO range is the default preferred manufacturer, but the Contractors must check the specific requirements before purchase and installation.

DB's shall be rated for 400/230V 50Hz with current ratings in accordance with the Contract Documents and constructed and dimensioned to withstand a minimum short circuit of 16kA. Distribution Boards shall be fitted with either three phase or single phase pan assemblies. Separate busbars shall be provided for neutral and earth conductors. The main incoming cable shall connect to a main board isolator or MCB (as specified) which can be locked in the off position. All unused outgoing feed terminations shall be shrouded and made safe. Surge protection equipment shall be fitted to the incoming supply point as a minimum.

Sufficient space shall be available on the top and bottom of the DB's for glanding and spreading of all the cables detailed in the schedule and specifications. Gland plates and spreader chambers shall be so constructed so as not to put any undue strain on the cables, terminations or terminals. Where specified aluminium gland plates shall be provided.

Identification labels shall be provided on all incoming and outgoing circuits, including cables.
DB's shall be equipped with an incoming isolator, miniature circuit breakers (MCB's) and or residual current circuit breakers with overcurrent protection (RCBO's), as required, with a minimum of 30% spare space for future expansion, whether spare capacity is scheduled or not. Scheduled spares shall be equipped with MCB's or RCBO's. Additional spare capacity shall be spaced such that only the insertion of MCB's or RCBO's is required to equip the space. Blanking covers shall be provided. Where the MCB board contains both MCB's and RCBO's separate terminals identifying both types shall be provided with labels and a DIN rail terminal divider.

MCB equipment shall conform to BSEN 60898, and BSEN 60947-2 B, C and D curves, be suitable for selectivity under short circuit conditions and shall have a minimum short circuit withstand capacity of 9kA, however exact short circuit withstand requirements shall be detailed out within the scope of works.

MCB's for the protection of lighting and control circuits shall be constructed in accordance with BS EN 60898 Type B or C, (as appropriate) characteristic or equivalent. MCB's for the protection of power and motor circuits shall be constructed in accordance with BS EN 60898 Type D characteristic or equivalent.

Individual socket circuits and circuits feeding mobile equipment shall be protected by RCBO's (earth leakage protection). MCB's and RCBO's shall be provided with trip free mechanisms assuring correct operation of the tripping mechanism even if the handle is held in the ON position against abnormal conditions. MCB's and RCBO's shall have a rated service life at full load of 20,000 operations. RCBO's and RCD's shall be A-type rated DC current component resistant.

Where Contract Documentation call for motor starters, these shall be mounted within the distribution board. The contactor shall have a utilisation category AC-3. Overload releases shall be triple-pole thermal overload devices Type 1 incorporating manual external reset, single phasing protection and ambient temperature compensation designated by the associated motor full load current, and shall be phase failure sensitive. The time-current characteristics of overload relays shall be given for each value of current.

Contactors for lighting switching and busbar trunking shall be mounted in a proprietary distribution board, contactor extension cubicles and rated for the expected load current and switching surges on all phases.

All internal wiring shall be neatly dressed and stress free and shall loop into the final connection point. All cores shall uniquely identified with the circuit breaker way and phase, associated earth and neutral wires/cores shall be identified with their corresponding circuit breaker reference with an N or E suffix to suit.

Circuit breakers serving hazardous areas shall be double pole to break single phase and neutral.
All electrical panels greater than 30kg shall be furnished with lifting lugs or eyebolts specifically designed for ease of handling during installation. The Supplier shall pay particular attention to providing stable panels (eg, not top heavy). Where, due to design reasons, this cannot be wholly achieved, the Supplier shall provide markings on the panels and on the individual panel shipping sections clearly indicating the hazards involved with the handling of the panel, including section weights and any special lifting instructions. These hazards shall be highlighted in advance of shipping to the material handling personnel.

The contractor shall submit all of the technical documentation for the distribution board for approval prior to purchase and install.

The Contractor shall submit the distribution board schedule for approval prior to installation.
The Contractor shall reference the circuits as per the distribution board schedule and attach the reference next to each circuit breaker inside the distribution board.
The Contractor shall attach/stick a copy of the distribution board inside the distribution board.

Y10 Equipment Mounting

The Contractor shall supply all equipment, fixtures, materials, supports, tooling, labour, and any associated miscellaneous materials required to position, mount/fix, and install electrical equipment and materials.

Contractual layout drawings supplied show the indicative locations for electrical equipment, electrical junction boxes and panels complete with indicative primary and secondary cable support routes. Although this information is quite detailed, It is the Contractor duty to define the exact detailed position of this equipment/materials by coordinating works with other site disciplines, electrical engineer and other site Management/Engineers to produce a fully coordinated installation, fit for purpose and complete in every way.

Equipment shall be, wherever practicable, positioned in safely and permanently accessible locations, from ground, platforms and walkways. Where permanent accessibility is impossible, equipment may be located where access can be achieved using temporary facilities (ladders or mobile platform). All equipment that requires operator action, regular maintenance or inspection, provides information, safety critical, requires manual operation, or provides a vital function shall always be thoughtfully positioned in easily accessible locations, configured and oriented appropriately for ease of use and/or maintenance, following manufactures instructions.

Electrical equipment, instruments and other equipment shall be mounted to avoid sources of heat and vibration. Equipment shall not be mounted/fixed directly to Handrails, pipework or other

equipment. Follow guidelines given in section 4.2 'Supports and Hangers' for acceptable fixing practice and consult manufacturer's installation guides.

Equipment shall be located such that it is protected against direct drainage of condensate, water and process fluids from adjacent plant equipment that can make the instruments, instrument components, junction boxes, etc. dirty, wet or inoperable.

The equipment shall not be located adjacent to equipment with radial/thermal heat emission. The equipment shall be suitably IP rated for the environment that it is installed in.

Installed equipment shall not block or obscure passageways and exits and shall not introduce confined space restrictions. Equipment and materials shall be thoughtfully positioned to allow ample space to perform service works and safe removal of inspection covers.

Blowout devices shall not be impeded in their operation by supports, thermal insulation or heat tracing.

Y11 Cable Phase Colour Coding

Low voltage (and medium voltage, where applicable) cabling shall be coloured in accordance with the following (to BS 7671) unless otherwise specified in the Contract Documents.

First Phase	Brown
Second Phase	Black
Third Phase	Grey
Neutral	Blue
Earth	Green/Yellow

Y12 Isolation

Safety isolators shall be provided with pad-lockable facility on control panels, motor starter drawers, VSD's etc. to isolate power and control supplies. Safety isolators shall be interlocked with panel doors to prevent opening of the panel whilst conductors are live.

Provision shall be made for isolating every circuit from the live supply conductors. Means of isolation shall be provided where maintenance of electrically activated equipment might involve a risk of physical injury and also to prevent danger in an emergency situation.

In certain instances (equipment with rotating elements) an emergency lock stop shall be provided (as specified within the particular specification) in combination with a local isolator. Emergency lock-stops shall not be utilised for isolation purposes. Padlock off facilities shall be provided at each motor, or fixed equipment being served.

Y13 Equipment Identification

The Contractor shall be responsible for ensuring that all items of electrical equipment and materials are adequately labelled as required by the Contract Documents, BS 7671 Requirements for Electrical Installations and good installation practice.

Labels shall be provided for the following purposes:
Identification
Equipment Rating

Safety/Warning Notices
Instructional Notices

Electrical equipment (switchgear, transformers, etc.) shall be provided with identification, rating plates and labelling in accordance with the approved Supplier's drawings. The Contractor shall supply any missing, incorrect or damaged labels.

The Contractor shall bring to the electrical engineer's attention any deficiency in identification and labelling.

Labels shall be traffolyte laminate, engraved with black characters on a white background and fixed with stainless steel screws. Warning labels shall have Black characters on a Yellow background. All instruments socket outlets, spurs, junction boxes, emergency stop push buttons, isolators, switches etc. and items of fixed equipment shall be clearly labelled with a unique identification/circuit number.

Y14 Inspection, Testing and Pre-Commissioning

Y14.1 Terminology

- Inspection - shall mean thorough visual and physical inspection to check for damage, quality of manufacture and installation, suitability of purpose, earth arrangements, connection details of installed equipment/materials and accuracy in conformance with the design and contractual documentation.
- Testing - shall mean all electrical tests, both live and dead tests.
- Dead Tests - includes Insulation and dielectric tests. Impedance tests and continuity tests. Tests required before circuits can be made live.
- Live Tests - these tests include prospective earth fault tests, rotational tests, voltage tests, earth leakage tests, calibration and settings, and functional tests
- Pre-Commissioning - shall mean all final checks, tests and energisation necessary to ensure that each circuit and its services perform their required functions satisfactorily
- Commissioning - shall mean all final functional tests, fine tuning, system tests.

A distinction exists between Electrical Testing and Electrical Commissioning. Testing is a sequence of activities the purpose of which is to determine the safety of an electrical installation in accordance to standards, in this instance, British Standards. Commissioning is a sequence of work activities which ensures that the installation functions as per the design performance parameters.

Y14.2 Test requirement and considerations

Electrical testing shall be conducted in conformance with BS EN 7671 and BS EN 61557 all parts. After erection of the electrical equipment and completion of electrical installation and connections, the Contractor shall carry out Inspection, Testing, Pre-Commissioning and commissioning to prove conformity to the Contract Documents and to the applicable Regulations and Codes of Practice listed in Section 2 of this Specification.

The Contractor shall submit a method statement of test procedures to the electrical engineer for review and approval prior to work commencement. The Contractor shall produce a test protocol document detailing all proposed tests to be performed. The test protocol shall describe in detail the method to be employed for the inspection, testing and pre-commissioning of each type of equipment, the record sheets to be used and the maximum and minimum test values of the expected results to be shown as applicable.

Electrical testing shall be conducted in a safe methodical manner. Test results shall be tabulated and checked to the relevant 'standard' criteria. Tests can only be performed once all the electrical installation works is complete.

Electrical Testing shall be methodical and shall only be conducted by suitably qualified Engineers. A safe system of work shall be employed during all testing and commissioning works that shall comprise of a permit to work system coupled to a lock off/tag off procedure, where all circuit feeders shall be pad locked off/tagged off and test Engineers/staff request access via a permit to work procedure. It is the responsibility of the testing/commissioning contractor to produce a viable method statement and risk assessment to help define the precise details of a safe system of work. This safe system of work shall be reviewed by site HSE and key site Engineering staff, to determine and test whether the safe system of work devised is a viable, practical and safe working system. The site Management and Engineering reserves the right to witness all tests and shall be given adequate notice prior to their commencement.

Accurate records shall be kept for all checks and tests. Record sheets shall be signed by the Contractor's representative and transmitted to the electrical engineer for review. Record sheets shall be retained by the Contractor for handing to the electrical engineer upon completion of the contract and for inclusion in the handover documentation. Test results shall be documented and signed by a qualified person.

The Contractor shall provide all test equipment, appliances, instruments (calibrated to national standards), labour and other facilities required for testing and pre-commissioning. Current calibration certificates which can be readily cross-referenced to the Contractor's Test Certificates shall be submitted for each test instrument used and incorporated in the handover documentation. Each Test Certificate submitted shall include a complete identification number for the test instrument used.

When specifically required the manufacturer's representatives shall be available for supervisory guidance for the testing and pre-commissioning of major items of equipment. This does not relieve the Contractor in any way from the responsibility of providing competent and suitably qualified personnel. The Contractor shall co-ordinate/arrange for site testing of all items in his scope of supply by manufacturer's representatives where required.

The Contractor shall offer all items of equipment for inspection, examination and witness testing and shall inform the Electrical engineer of the date when the plant shall be ready for inspection and witness testing. If the tests are beyond the resources of the Contractor, he shall plan for these to be carried out by the manufacturer's representative. This requirement shall be agreed and confirmation in writing obtained from the electrical engineer.

The Contractor shall carry out performance tests and such other tests as are necessary, in the opinion of the Electrical engineer, to determine that the plant complies with the Specification, either under test conditions in the manufacturer's works, on Site or elsewhere or in ordinary working conditions.

Any equipment used in the testing of the plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the plant and the men working thereon.

Y14.3 Inspections

Inspections can only be performed when all electrical equipment installation works are fully complete. All of the electrical installation shall be subject to a complete visual inspection. The inspector shall tabulate observations made during visual inspections, which shall cover all of the main check points subject to verification before applying electrical power. Deviations and defects and all corrective or rectification works shall be highlighted for remedial works.

Some of the main inspection check points are, but are not limited to:

- Compliance to contractual drawings, contractual specifications, material specification, correction of components, equipment specification.
- Installation accuracy to drawings, design information, manufacturer's instructions, and contractual documentation.
- Cable support system for defects, installation quality, rigidity/stability, earth bonding, continuity, capacity, alignment, sharp edges, fixing tightness, support brackets and overall appearance.
- Cable installation for insulation damage, cable dressing, cleats/supports, glanding, cable identification, termination tightness
- Installation earthing arrangements, earth bonding, supplementary bonding, CPC installation, accuracy to drawings, conformance to standards, design and contractual information.
- Equipment installation, positioning, accessibility, means of anchorage, accuracy, cleanliness, manufacturers rating plate details, capacity, means of local isolation, signage, earth arrangement, interlocks and guarding, alignment and conformance to manufacturers installation instructions, and contractual documentations.
- Mechanical and electrical interlocks, door and isolating handle interlocks, Castell key interlocks, etc.
- Correct equipment degree of protection, particularly with regard to cable gland entries.
- Padlocking facilities
- Torque test on random bus-bar bolts and on the switchgear panel assembly
- Visual inspection to check if the labels are correct, check for scratches and possible defects
- Correctly fitted guards and protective covers
- Correctness of equipment component parts to 'Issued for Construction' and to manufacturer's drawings.

Y14.4 Dead tests

Electrical installation dead testing shall comprise of the following tests as minimum requirement.

- Continuity Checks
- Insulation Resistance and Dielectric tests on all cables, switchboards and MCC's prior to power on
- Impedance Tests
- High Voltage Tests
- Earth impedance tests
- Earth bonding tests

Y14.5 Live tests

Electrical installation live tests shall comprise of the following tests as minimum requirement.

- Earth Loop Impedance
- Voltage tests
- Prospective Fault Current Test
- Polarity Checks

- Phase rotation
- Effectiveness of earth leakage protective devices

Y14.6 Switchgear/MCC's

Where switchgear and MCC panels and similar equipment is part of the contractors scope of supply, the following tests shall be performed as a minimum requirement:

- Visual Inspections
- Insulation Resistance
- High Voltage Tests
- Polarity
- Continuity of Busbars
- Primary/Secondary Injection of CT's and VT's
- Instrument Function/Operation
- Protection Relay Function
- Operation

The Contractor shall undertake a full discrimination study using proprietary software to confirm all breaker trip settings prior to commissioning. This includes HV/MV and LV breaker trip settings. The study shall be issued in table format clearly identifying all breakers entire parameters and corresponding cable supplies.

In addition, the contractor shall provide all trip setting parameters on power supplies to VSD driven equipment.

Y14.7 Transformers

Where transformers are part of the Contractor's scope of supply, the following tests shall be performed as a minimum requirement:

- Visual Inspections
- Primary/Secondary Insulation
- Resistance
- Primary/Secondary High Voltage Tests
- Dielectric Tests
- Function Bucholz (Pressure) Device where provided
- Function Oil Temperature Device if relevant
- Function/Setting Tap changer
- Oil Condition if relevant

Y14.8 Motors:

- Direction of Rotation ('bumping' motor drives shafts for correct rotation, etc.)
- Overload Protection Operation and Setting to Correct Value
- Insulation Resistance
- Isolator/Emergency stop function check
- Correct operation of any hardwired safety devices
- Correct starter operation

Y14.9 MV Cables (where part of the Contractors scope of work)

- Insulation resistance
- Phase Rotation
- High voltage (pressure test - twice system voltage for 15 minutes) or as advised in the particular specification or manufacturers recommendations.

Y14.10 MV Switchgear (where part of the Contractors scope of work)

- Function Checking/Commissioning of Tripping Alarms, interlocks etc
- Insulation Resistance Test
- Relay Protection Primary Injection and Settings
- Verification of earthing arrangements
- Pre-installation Testing

Y14.11 Pre-commissioning

Once all electrical tests are complete pre-commissioning tests shall be performed on electrical equipment, assemblies, sub-assemblies.
These tests shall include but not limited to the following:

- Voltage tests.
- Operational tests.
- Safety circuit tests including interlocks and guarding.
- Motor operational tests including rotation tests, Isolator emergency-stop & interlock tests. overload protection setting/tuning and checking/tabulation of operational parameters.
- Lighting operational tests which shall include illumination levels, emergency lighting tests & certification. Correct operation of lighting controls.
- Fire detection system tests.
- HVAC operational/performance tests.
- Instrumentation tests which shall include loop tests, power off tests, set up and functional tests.
- Protective relay fine tuning and operational tests.
- BMS system functional tests

Y15 Miscellaneous Installations

Special installations shall be checked according to the Manufacturers' instructions and/or agreement with the Electrical engineer.

Trips and alarms not previously covered in the loop tests, eg, initiated devices which stop/start pumps etc, shall be checked out in conjunction with the electrical engineer.

All systems shall be checked for 'fail safe' operation which will include the checking of 'burn out' features on installation.

Y16 Certificates

The following test/completion certificates shall be completed and handed over to the Client:

- Cable test sheet for all cables.
- Instrument loop check sheet.
- Instrument pre-installation calibration sheet.
- Alarm system check sheet.
- Calibration check sheet.

Y17 Spare Parts

The Contractor shall provide a comprehensive spares parts list which shall cover 2 years operation. Spares parts lists shall be handed to the customer for appraisal, and shall be included within the final O&M manuals.

All spare parts shall comply with the same specifications and tests as the original equipment and shall be fully interchangeable with original parts without requiring further site modification.

Consumable spares shall be purchased by the contractor and included within the scope. Two years of consumable spares shall be purchases, as recommended by the equipment manufacturers.
All commissioning spares shall be purchased by the contractor and included within the scope. Commissioning spares shall be handed over to the customer on contract completion.

They shall be correctly marked with reference numbers and the manufacturer's part numbers and shall be properly protected to prevent deterioration during shipment and storage. All spare parts are to be separately boxed in order that they may be taken into the Contractor's stores immediately on delivery, checked by the Contractor and repacked.

Electrical equipment in particular shall be packed in sealed polythene or similar bags with a liberal supply of desiccant and secured with tongued and grooved boarded cases.

Y18 Civil Works

The Contractor shall be deemed to have examined the drawings and the site, specifications, existing buildings and any adjoining property, structures, etc., to have informed himself of all items connected with the works. The Electrical Contractor shall also be fully aware of the existing site main infrastructure, buildings and general services layout, contractual geographic scope, site movements and rules & regulations. Where a flood risk assessment has been carried out, the Electrical Contractor shall request these from the main contractor and be fully aware of its contents and potential risks prior to any installation work been undertaken.

The Contractor shall supplement the information given to include all incidental or contingent works necessary including Contractors work.

The Contractor shall provide and set in place, or cause to be set in place, proper anchor bolts complete with nuts and washers for all apparatus installed by him.

The Contractor shall be responsible for his employees conforming to the HSE Safety Regulations in force at the site and to the statutory requirements as they relate to the site. The Contractor shall be particularly responsible for the electrical safety especially during testing and commissioning.
Unless otherwise specified all excavating and backfilling will be carried out by others. However, it is the responsibility of the Contractor to ensure that the requirements of the specification and drawings such as routing, depth and backfill are complied with.

All marker tape and marker slabs specified shall be supplied and installed by the Electrical Services Contractor in conjunction with the backfilling work. Cable warning tape shall be 150mm wide, yellow PVC tape with the words ‘DANGER ELECTRICITY CABLE BELOW’ printed in black.

The Electrical Contractor shall be prepared to assist the civil contractor when performing critical works like initial backfill of buried cables, setting out works and dimensioning to ensure that the equipment and installation is installed to specification and remains damage free.

All cutting and repairing of completed work which is required for the installation of this contract will be done by the respective Contractors for the various trades involved.

The Electrical Contractor shall coordinate any civil work requirement in a timely manner, which coincides with the site work activities or discussed in the site coordination meetings. The Electrical Contractor shall be responsible for all works performed by others on their behalf, which includes civil activates conducted under their guidance.

The Civil Contractor will provide opening in the floors, walls, ducts under walls/roads etc. as required for the installation of the services and equipment, provided that the necessary information regarding such openings is furnished to him by the Electrical Contractor at the proper time to enable him to 'build them in'.

Failure on the Contractor's part to furnish the proper information regarding the required openings will necessitate there being cut and repaired at the Contractor's expense.

Y19 Equipment and Materials

Equipment and materials to be supplied by the Contractor shall be as detailed to the construction issue documentation pack.

The equipment and materials listed as 'Free Issue' and 'Contractor Supplied' shall together be sufficient for the complete electrical installation. Any deficiencies shall be reported immediately by the Contractor to the Electrical engineer.

Y20 As Built Drawings

During the course of the works the contractor shall red line the construction drawings to indicate any additions or revisions to the installation. These red line drawings shall be available for inspection by the electrical engineer at all times during the course of the works.

Upon completion of the works the Contractor shall provide three complete sets of "As Built" drawings in paper format.

The Contractor shall also provide a soft copy of each of the "As Built" drawings on disc. The drawings shall be in the latest version of AutoCAD or Revit as required.

Y21 Operation and Maintenance Manuals

The Contractor shall provide Operating and Maintenance (O & M) manuals, presented in hard back bound 4 ring folders (three copies). A draft form O & M manual shall be presented to the customer for approval 30, days prior to testing works. The final O&M document shall be submitted prior to formal handover (15 days following practical completion), and shall be a condition of final payment. The manuals shall give clear unambiguous information about all of the items of plant and equipment supplied and installed under this contract. Manuals binders shall not be over-filled and shall have clearly labelled binders. The contractor shall include any "Free Issued" equipment and incorporate these into one overall O&M manual.

Y21.1 Products

Y21.1.1 Manual Organisation

Contents

Provide index page of contents.
Tab manual with labels for the following:

- Contents
- Contractor Data
- Operating and Maintenance Instructions (by System)

Contractor Data

Provide project name, address and date of substantial completion.

- Provide names and addresses of:
    - General Contractor
    - Mechanical Contractors
    - Electrical Sub-Contractors
    - Equipment Suppliers

Operating and Maintenance Instructions (by System)

Provide the following for each system as indicated in the generic table below.
Refer to manual matrix for specific requirements for each system.

O&M Manuals (Typical System)

- System Outline General System Overview

- System Identification:
    - Detailed System Description/Function Specs.
    - Equipment Schedule
    - Instrument Schedule
    - Supplier/Contractor Document Index

- Equipment Plant Details:
    - Specific Equipment Front Sheets (Serial Nos.) Etc.
    - Manufacturer/Supplier Schedule
    - Data Sheets
    - Performance Data/Catalogue Cuts
    - Noise Level Data
    - Instrument Schedules
    - Modification Information
    - Disposal Details

- Equipment Drawings:
    - Manufacturer's Drawings (Assembly)
    - Manufacturer's Drawings (Sections)
    - Elec. Wiring Diagrams
    - Control Diagrams/Data

- Operation:
    - Operating Checklists
    - Operating Instructions

  - Cleaning Instructions
  - Safe Operation

- Maintenance:
  - Maintenance Instructions
  - Operation and Maintenance Schedule
  - Lubrication Instructions/Schedule
  - Troubleshooting Information
  - Spares List/Storage Instructions
  - Spares Drawings
  - Special Tools
  - Special Test Equipment
  - Sample Service Agreement

- System Drawings:
  - As-Built Schematics
  - As-Built Layouts
  - As-Built Isometrics

- Circuit Index Charts
  - Circuit Index Charts

- Test/Conformance Certs (Equipment):
  - Material Test Certs
  - Conformance Certs
  - Manufacturer's Test Certs.
  - Cleaning/Flushing Certs.
  - Pressure Test Certs.
  - Elec. Test Certs
  - Warranties/Guarantees
  - Instrument Calibration Log
  - Safety Check/Fire Certs
  - Instrument Calibration Certs
  - Insurance Details

- Test/Conformance Certs (Site):
  - Polarity Check Lists
  - Earthing Check List
  - Line Earth Loop Impedance Measurement
  - Insulation Resistance Measurements
  - RCD's Verification
  - Ring Circuit Continuity Check List
  - Phase Sequence Check List

- Commissioning
  - Calibration Charts/Certs (Commissioning Equipt.)
  - Equipment Test Reports
  - Equipment Installation Checklists/Certificates
  - System Checklists

- System Acceptance Certificate
- Lighting Level Tests

- Commissioning (Electrical):
  - Function Check Sheet
  - RECI Completion Cert
  - ERI Completion Cert

- Procedures: Listed in Specs.

Y21.2 Warranties

Provide validation reports and test reports for all trades including controls checklists.
Provide copy or statement of the general warranty of the Contract (or Electrical Sub-Contracts), including the dates of the warranty period.
Provide copies of vendor (equipment manufacturer) warranties, specifically including those manufacturers who warranty their product for more than one year.

Y21.3 Organisation of Manual

Quantity

Provide Operation and Maintenance Manuals as follows:

- Provide three (3) hard bound copies of the completed manuals with information on all equipment installed within the project including manufacturer's literature and As Built drawings. One copy will be retained by the Electrical engineer and the other two are for the Owner's use.
- Also provide 2 soft copies of the above information as pdf files and .dwg/.rvt files on USB disks

Split of Manual

The maintenance and operating section shall be split by system.

Each system shall include details of each piece of equipment, including instruments and, actuated and manual valves as appropriate.

A typewritten front sheet shall be provided for each piece of main equipment which should include the following information:

- Equipment Tag Number
- Description
- Make/Model/Type
- Serial Number
- Manufacturer's and Local Agents Name, Address and Telephone Number

Drive Motor Details as Follows:

- Motor Manufacturing
- Type
- Frame Size
- kW Rating
- FLC
- Voltage
- RPM

- Warranty Dates

A front sheet shall also be provided for each type of luminaire, accessory and cable and should include the following information:

- Tag Numbers
- Make/Type
- Size
- Material of Construction
- Manufacturers Name
- Local Agents Name, Address and Telephone Number

A price list of recommended spare parts for 2 years operation. Note spares will be purchased directly from the manufacturers/agents by the Client.

Catalogue cuts of equipment shall be provided.

Operating Instructions
Provide typewritten operating instructions for the owner which should include actual cable and equipment tag number. This should be written specifically for the actual installation.

Describe how to start or stop each electrical system or individually controlled piece of equipment. Describe how to set the control system for normal operation, emergency shutdown and normal restart procedures after power failure.

Lubrication schedule
Describe all caution or warning notices posted on or with the equipment or systems.
Describe the interlocking switching procedures and key arrangements along with diagrams/instructions.

General Requirements
Provide copy of all approved submittal data, shop drawings, test certificates etc. As finally provided on this project.

Each piece of submittal data should describe material or equipment actually installed on this project. Annotate final commissioning reports with any changes which occurred since publication of the final report.

Y21.4 Execution

Delivery
Submit draft manual to the engineers for approval 30 days prior to beginning of test and balance work.

Provide the manuals for handover to the owner during the formal demonstration/handover meetings of the electrical systems.

Deliver the final manuals to the Engineers prior to submitting application for final payment.

Y22 Warranty & Guarantees

All Warranties shall cover all parts and labour for a minimum twelve (12) month period from practical completion. All manufacturers' warranties and guarantees where applicable, shall be passed onto the customer, the end user, at the end of the 12 month warranty period.

Vendor shall with all possible speed replace or repair at Vendor's cost any part of Goods which is or becomes defective during a period of 12 months from practical completion, where such defects are due to faulty design (other than designs made, furnished, or specified by Client for which the Vendor has disclaimed responsibility in writing prior to commencing manufacture), Vendor's erroneous use of data, or inadequate or faulty materials or workmanship, or any breach of Vendor's warranties, expressed or implied. Replacements and repairs shall themselves be subject to the foregoing obligations for 12 months from the date of reinstallation or passing of tests, (if any) whichever is appropriate after replacement or repair. The purchaser shall notify the Vendor of any such defect upon its discovery.

If it is necessary to return Goods or part thereof to the Vendor for the repair of a defect, the Vendor shall be liable for all costs and risks associated with the return and re-supply of Goods. The Vendor shall deliver the replacement or repaired Goods or part thereof at the Vendor's cost or terms acceptable to Purchaser. Purchaser's rights under this Clause shall be assignable to Others.
In the event that the Vendor cannot respond or rectify the defect in a time acceptable to the Purchaser, the Purchaser may carry out the replacement or repair and shall be entitled to reimbursement by the Vendor for Purchaser's reasonable costs incurred in the removal and/or dismantling of such defective Goods and the reinstallation of the replaced or repaired Goods. Such actions shall not relieve the Vendor of continuing obligations under Purchase Order.

Y23 CE Marking

All equipment, components of equipment and system supplied shall conform to all appropriate and applicable UK legislation and EU Directives and shall be CE-marked. In particular, all machinery supplied shall comply with Directive 2006/42/EC of European Parliament (the EU Machinery Directive) and all pressure equipment supplied shall comply with Directive 2014/68/EU (the EU Pressure Equipment Directive).

All equipment and components of equipment supplied for use in a potentially explosive atmosphere shall be appropriate for use in particular environment and must comply with the EU 'ATEX' Directive 2014/34/EU. In particular the equipment must be marked with all information essential for its safe use including comprehensive EX-marking showing equipment group, equipment category, and Gas/Dust suitability. The Supplier's documentation shall include a declaration of conformity with the ATEX Directive.

For electrical equipment and systems within the scope of supply, the Supplier's documentation shall include Declarations of Conformity for electrical equipment as required by the EU Machinery Directive, the Low Voltage Directive (Directive 2014/35/EU) and the Electromagnetic Compatibility Directive (Directive 2014/30/EU).

In respect of safety systems and/or safety instruments related to the control systems for any of the equipment, machinery, materials or packages (or components thereof) supplied the Supplier shall provide confirmation in the tender that compliance with the following standards (as applicable) has been met: ISO 13849 (which supersedes EN 954), EN 61508, EN61511 and EN 62061. If such

conformation is not provided then the Supplier must provide details of what (if any) equivalent standards or methodology have been adhered to.

The Supplier shall have accurately compiled the necessary Technical Files or Technical Construction Files to demonstrate the appropriateness of the affixing of CE marking and these files (and all the other relevant documentation) shall be available to the Purchaser on request prior to installation and at all times during the life of installation.

Compliance of the equipment and components supplied with appropriate EU and UK legislative requirements and standards is the sole responsibility of the Supplier, regardless as to whether the equipment or components in question are sourced from inside or outside the EU, from a sub-supplier or from any other third party.

If the Supplier deems that his equipment must be further assessed or certified as part of the larger system to which it will finally be connected, this shall be highlighted in the Supplier's tender. The Supplier shall outline in the tender the extent to which they deem themselves responsible for the certification and marking of the system and the extent to which this will be dependent on the other parties. This shall be discussed and agreed with the Purchaser prior to issue of the Purchase Order, and failing such discussion and agreement sole responsibility shall revert to the Supplier.

Y24 Schedule of Manufacturers

Description	**Reference**	**Manufacturer/Supplier**
Distribution Boards and MCCB Panel boards	Complete with Integral Isolators and Metering Kits	Schneider Eaton
Cables	LV sub main power, Final circuit wiring for Lighting and power and fire alarms	CPR Compliant BASEC Approved Manufacturers - Draka, Lapp, Eland, BATT cables and Pryamian
Cable containment	For Power cables Lighting, Power, General Services, ELV services etc	Unitrunk, Legrand UK, Eaton Metsec, Amorduct Or equal
General and Emergency Luminaires	Refer to Drawings and model for details	Luceco Sera LED Lighting Unless otherwise specified in the luminaire schedule
Lighting Controls	Refer to Drawings	CP Electronics
Earthing Equipment		Furse ABB
Dado Trunking	classrooms	MK Electric Limited – Prestige 3D
Local Isolators	General and IP Rated	Eaton or equal
Contactors		Eaton or equal
Wiring Accessories		MK Electric Limited – Logic Plus MK Electric Limited – Metalclad
Data Outlets	RJ45	MK Electric Limited – Logic Plus