



ELECTRICAL SPECIFICATION

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REVISION E

DESIGN REQUIREMENTS

The point of connection to existing systems shall be evaluated to ensure that there is adequate existing *spare* capacity on the existing system to meet the new demand. If there is any doubt then this should be validated. The designer or contractor is responsible for ensuring that there is adequate existing *spare* capacity to meet the new demand. The general expectation is that where an area is being refurbished on a general like for like basis, load will be reduced.

The proposed point of connection needs to be *properly identified and agreed* to ensure there is adequate capacity for the load and that existing installations will not be compromised.

The point of connection shall incorporate earth fault protection such as VIGI type equipment.

Consideration should be given as to the *appropriate time* to make the connection(s), to avoid user impact as far as possible.

If required the connection works should be brought forward to minimise the impact of the works.

Protection of plant. All plant shall be protected by suitable protective devices. The devices shall be sized and selected to allow adequate discrimination between devices.

Isolators local to plant and equipment shall isolate all phase conductors and the neutral conductor and accept a standard CU padlock for isolation.

The following requirements are mandatory and must not be varied or otherwise relaxed.

Prior to any design being prepared the consultant/contractor shall prepare a single line diagram of the existing distribution and shall determine the maximum demand of each point of utilisation. The design shall demonstrate that existing loads and the proposed new load(s) are within the safe working capacity of the system.

Single line diagrams that show any part of the electrical distribution shall have the distribution elements, that is the circuit breakers, switch fuses, cables and distribution boards identified with its reference and City University asset code, each element shall also have its location shown.

Layout drawings that show the electrical distribution elements, that is the switchboards, MCCs and distribution boards shall show an ident which shall be cross referenced in a table on the same drawing.

For switchboards the table shall include in addition to its system reference and asset code, the voltage e.g. 400Vac; busbar rated current e.g. 2500A; the short circuit level and time e.g. 50kA 3secs;

For distribution boards the table shall include in addition to its system reference and asset code, the distribution board configuration e.g. 6W SPN MCB board; Incomer e.g. 2P 125A switch; manufacturer/type e.g. Schneider Electric Ltd. Type A; Supply reference e.g. TAIT-L0-LV-SWG-010; Supply device e.g. 2P 50A MCB; Supply cable e.g. 2c 25mm² Cu XLPE:LSZH(EB):LSZH:SWA

The asset code for every item of new equipment shall be issued, upon request, by City University Operations Department. Designers and contractors shall submit a list of proposed new assets, in CU format at the earliest opportunity in the process.



To minimise spares stockholding, provide a uniform installation both in quality and manufacture, also for the maintenance staff equipment familiarity, their safety and to minimise their training on new equipment the manufacturer of various components of the distribution equipment is stated within this specification. This does not preclude other manufacturer's equipment being offered however the University will give preference to those offers that include the preferred manufacturers.

To enable sensible planning of a distribution system design guide lines have to be established. For outline planning the following load should be used as a maximum figure to include small power, lighting and all plant, the outline should be replaced by the actual loads as detailed design proceeds. The initial maximum load is 25VA/m².

The final distribution system is from the distribution boards to the points of utilisation. The minimum size of conduit wiring to be used for lighting circuits is 1.5mm² with LSZH insulation and stranded conductors, for socket outlets and fixed appliances the minimum size of conduit wiring to be used is 4mm² with LSZH insulation and stranded conductors.

Any conductors concealed within 50mm of surface of walls or ceilings must be contained in or protected by earthed rigid metallic conduit.

For non-common areas; that is areas other than those normally referred to as landlord areas the following shall apply.

Each room shall have a dedicated circuit or for larger rooms circuits for its lighting all fed from the same phase.

Each room shall have a dedicated radial circuit or for larger rooms circuits for its socket outlets, each circuit shall supply no more than 50m², or 6 desk positions, the socket outlet circuits in any room shall all be fed from the same phase. The circuits shall be radial and on the same phase as the lighting circuit(s) in that room.

Where a room has fixed appliances with loads up to and including 32A single phase those loads shall be individually fed. The feed shall be the same phase as the lighting and socket outlet circuits.

Except for plant rooms the distribution board supplying a room shall be external to the room and local to it. The board shall feed up to three immediately adjacent rooms. For purposes of standardisation the distribution boards shall be selected from the Schneider Electric Ltd. Acti 9, single phase distribution boards with 125A two pole incomers, the preferred board being 6 way which has the catalogue number MGAN6. The board shall be fitted with a lock that shall be supplied and fitted by City University Operations Department. The MCBs shall be type C rated at 10A for the lighting and 20A for the socket outlet circuits, the ratings and types of MCBs for fixed appliances shall suit the appliances being fed. The board shall be mounted with lid hinges on the left hand side.

For landlord areas which includes staircases, corridors, toilets, lift lobbies and reception areas the following shall apply.

Each staircase, corridor, toilet, lift lobby and reception area room shall have a dedicated circuit or for larger areas circuits for its lighting all fed from the same phase.

Each staircase, corridor, lift lobby and reception area room shall have a dedicated circuit for its socket outlets, generally each circuit shall supply no more than 50m² all fed from the same phase. The circuits shall be radial and on the same phase as the lighting circuit(s) in that area. Cleaners outlets shall be a distinctive colour as agreed with City University Operations Department.

Where there are fixed appliances with loads up to and including 32A single phase those loads shall be individually fed. The feed shall be the same phase as the lighting and socket outlet circuits in that area.



Corridors shall for the purpose of this requirement be deemed to be self-contained spaces between doors joining corridors or the interface point to lobbies, staircases or other areas.

The distribution board supplying the landlord's areas shall be located in the electrical riser cupboard of each core area or other accessible location, and preferably be combined with the three phase non-landlord's distribution board. For purposes of standardisation the distribution board shall be selected from the Schneider Electric Ltd. Acti 9, single phase distribution boards with 125A two pole incomers, the preferred board being 12 way which has the catalogue number MGAN12. The board shall be fitted with a lock that shall be supplied and fitted by City University Operations Department. The MCBs shall be type C rated at 10A for the lighting and 20A for the socket outlet circuits the ratings and types of MCBs for fixed appliances shall suit the appliances being fed.

The distribution boards that feed the non-common areas shall be themselves fed from a three phase distribution board, and preferably be combined with the single phase landlord's distribution board located in the riser cupboard of each core area. For purposes of standardisation the distribution board shall be selected from the Schneider Electric Ltd. Acti 9 type B three phase distribution boards with 160A four pole incomers, the preferred board being 24way three phase which has the catalogue number MGBN24 fitted with a distributed neutral bar catalogue number MGNB24. The board shall be fitted with a lock that shall be supplied loose to the contractor by City University Operations Department. The outgoing MCBs shall be type C 2 pole rated at 50A and fitted with Vigi earth leakage units catalogue number C60H250 + 26806.

Each of the boards in the riser cupboard, that is the non-common areas and the landlords distribution boards shall be metered using a Schneider Electric Ltd. PM5563 series multifunction meter. Split load boards shall not be used. Use dedicated boards for lighting or power, however it is essential that the two boards have separate metering. That metering shall be compatible with the site SCADA system to which it shall be connected.

The boards in the riser cupboards may be fed from busbar risers or via cables from a secondary distribution board or switchboard. Proper electrical discrimination shall be achieved. It is for the designer / consultant / contractor to determine the most economic installation. Factors that should be included in that consideration are the ability to re-use existing risers, the availability of tap off units and other spares, the disruption caused during the replacement of busbar risers, the cost of introducing additional distribution panels and cabling. Where it is decided to install a secondary distribution board or switchboard the distribution equipment shall be drawn from the Schneider Electric Ltd. ranges of MCCBs and MCBs.

Plant rooms and areas should be considered as other non-landlord's areas and have lighting and socket outlet configurations as other non-landlord areas. For small plant with single or three phase power requirements a separate three phase and neutral distribution board shall be provided in the plant area to be served.

For plant areas with multiple motors consideration shall be given to replacing individual starters where they are provided or motor control centres where they are provided.

It is for the designer / consultant / contractor to determine the most economic installation or replacement for plant areas. Factors that should be included in that consideration are the age of the equipment, the availability of spares, the safety of the maintenance engineers when maintaining or operating the equipment, the need to remotely monitor and control plant.

Not only shall the replacement distribution equipment be considered, the consultant/contractor shall make every effort to consolidate the distribution system to provide additional spare circuits on the primary distribution boards. The object being to increase the number of spare ways on the primary distribution switchboards which are limited in size due to the overall lack of space within the University, and the inevitable issue of creeping load growth over the projected life of the primary distribution system.



Notwithstanding the requirement to comply with the IEE Regulations and the University electrical specifications the following requirements for the design and installation are in addition to those requirements.

The final circuits shall be designed for a maximum volt drop of 2% where the lighting points are taken as the actual load or 50VA per point whichever is the greater and 250VA per socket outlet, fixed appliances shall be taken as the actual load.

The secondary distribution system shall be designed for a maximum volt drop of 4% from the primary LV switchboards to the final distribution boards.

The consultant/contractor shall submit full calculations in Amtech format for every circuit.

Where armoured power cables are replaced or installed as part of the secondary electrical distribution system renewal they shall be terminated using E1W brass to BS 6121 glands that seal both the inner and outer sheaths to prevent corrosion to the armour and maintain its integrity.

Single cables in trunking shall be grouped in circuits and tied together using 3.5mm wide nylon cable ties at 1metre intervals.

Every switchboard, motor control centre, distribution board, and any other item of equipment supplied and installed as part of the refurbishment of the secondary electrical distribution shall be clearly marked with their system reference and asset code, the asset code shall be as issued by CUL Operations Department. Labels that advertise persons, companies, services or any information not required in this specification shall not be affixed to any item of electrical equipment.

Wires terminating in distribution boards shall be marked with 'O' type ferrule markers that enable the phase, neutral and where installed the earth wires of a particular circuit to be easily identified. Switchboards including motor control centres that have multiple termination chambers shall have the relevant compartment references marked on the termination chamber cover and internally to the chamber.

Testing

Every installation shall be tested as required by the IEE Regulations and the specifications issued by the City University Operations Department and the tests listed below and the relevant test certificates issued in CU format only. The City University Operations Department shall be given the opportunity to witness every test.

As switchboards are assembled on site from cubicles manufactured elsewhere the switchboards shall be tested as any other site assembled equipment with the addition of a milli-ohmeter test of every circuit, where every switch disconnector, fused switch and MCCB in the switchboard board is closed and then the resistance between the incoming terminals and the outgoing terminals of every circuit being measured and recorded.

As panel boards are assembled on site the panel boards shall be tested as any other site assembled equipment with the addition of a milli-ohmeter test of every circuit, where every switch and MCCB in the distribution board is closed and then the resistance between the incoming terminals and the outgoing terminals of every circuit being measured and recorded.

As distribution boards are assembled on site the boards shall be tested as any other site assembled equipment with the addition of a milli-ohmeter test of every circuit, where every switch and MCB in the distribution board is closed and then the resistance between the incoming terminals and the outgoing terminals of every circuit being measured and recorded.

Motor control centres present a difficulty in respect of the type of testing described above however the control power supply and control circuits shall be designed such that the contactors may be closed without the main



circuit being energised to allow the milli-ohmeter testing from the main incoming terminals to the outgoing terminals of each starter.

Redundant Equipment

Redundant equipment, cables and cable containment shall be removed from site only after the university facilities department have been given the opportunity to identify components to be retained for spares. The method of disposal of any electrical equipment shall comply in every respect with the WEEE Directive of 2006 as amended in 2009.

IT, AV and telecommunications infrastructure and cabling. Shall all be installed in dedicated containment systems (baskets, trunking and solid conduit), as the general electrical installation.

1 ELECTRICAL STANDARD

- 1.1.1 The aim of this standard is to contribute to a co-ordinated electrical distribution system. New installations and modifications to existing parts of the system could cause adverse consequences to other users within City University and to the public supply network.
- 1.1.2 To minimise spares stockholding, provide a uniform installation both in quality and manufacture, also for the maintenance staff equipment familiarity, their safety and to minimise their training on new equipment the manufacturer of various components of the distribution equipment is stated within this specification. This does not preclude other manufacturers equipment being offered however the employer will give preference to those offers that include the preferred manufacturers.
- 1.1.3 The University estate covers a number of sites. Each site has an electricity supply from the district network operator (DNO). That supply varies from dual 11kV supplies for the main campus to single phase supplies for smaller units of the estate. Various sites of the estate have standby generation facilities or CHP stations or renewable energy infeed's those sites have to comply with the requirements of the EA G59 code.
- 1.1.4 All proposed modifications to, or additions to or for additional loads to the electrical distribution system, without exception, must be approved in advance by the Operations Department. This includes submission of drawings and calculations in sufficient detail to allow the Operations Department to assess the proposed modification. The Operations Department has absolute discretion to accept or decline any proposed modification or to request additional information. Therefore Contractors, Designers and Consultants should allow adequate time for this process as the Operations Department will not allocate resources to this activity to meet external deadlines.
- 1.1.5 All LV devices down to main isolators on final distribution boards shall have the number of contacts equal to the number of wires in the supply, that is four pole for three phase and neutral supplies, three pole for three phase supplies and two pole for single phase and neutral supplies unless specifically agreed in writing in advance with City University Operations Department.
- 1.1.6 Any equipment, cables, containment made redundant by works, including containment and fixings are to be removed from site and disposed of in accordance with relevant regulations.
- 1.1.7 Any making good or fire stopping made necessary by the removal of redundant equipment, cables, containment and fixings is to be included in the scope of the works including making good to finishes.
- 1.1.8 Fire stopping works shall be certified by third party accredited companies.
- 1.1.9 All equipment to be included in any installation shall be of a type and duty appropriate for the intended use.

- 1.1.10 Where there is an ongoing maintenance requirement, designers shall ensure that there is full and proper access for maintenance without use of specialist access equipment. Generally all equipment requiring maintenance should be accessible without the use of ladders or other access equipment.
- 1.1.11 It is a fundamental requirement that all new plant and equipment can be accessed using at most a 1.8m step ladder and that persons of all heights and statures can easily perform any maintenance operation required.
- 1.1.12 Where controls or electronics are used these must be fully documented and of the open protocol type. No proprietary closed protocol equipment will be accepted under any circumstances.

2 CONTROL OF DOCUMENT

- 1.1.13 Prior to commencement of each project design, tender or installation ensure that the Specification is the current copy. Obtain any amendments or appendices from City University Operations Department. It is the Designers and/or Installers responsibility to check they are in possession of the latest issue.
- 1.1.14 The Specification shall be controlled by City University Operations Department. No copy, either in its entirety, or parts thereof, shall be taken during the design, tender or installation, without prior written permission of City University Operations Department. No modification, adjustment, alteration or amendment shall be made to the Specification without approval by the City University Operations Department.
- 1.1.15 Any anomalies, discrepancies or errors considered to be found in the Specification during design, tender or installation shall be identified to City University Operations Department for verification.

REVISION HISTORY			
REV	DATE	REVISION	BY
B	1/2/2012	General revision and update	DW
C	14/10/2014	General revision and update, SKA requirements added	DW
D	20/4/2016	General revision and update. Appendices added.	DW
E	15/6/2016	Revised to require LED / DALI illumination. Floor mounted power and data presentation specified.	DW



3 GENERAL

- 3.3.1 The Specification is intended to define and outline the minimum standards, including workmanship, safety, etc., expected from the Designer and/or Installer of Electrical Works at City University. It is not intended to be read in isolation, and careful cross-reference shall be made with all other City University Standard Specifications, Regulations and relevant Standards.
- 3.3.2 In the Specification when the word Installer is used, this shall mean the Designer, Consultant and/or Electrical Contractor appointed to carry out the design and/or installation, procurement and testing of the Electrical Engineering Services and Works.
- 3.3.3 If Particular Project Specification items are at variance with the Standard Specification sections then the Standard Specification shall take precedence. Deviations from this Specification shall not be permitted unless prior agreement is received in writing from City University Operations Department.
- 3.3.4 In the event of there being any discrepancy between the details of the Specification and the drawings, or if there are any matters which are not fully understood, then these must be notified to City University Operations Department for clarification before submission of the Design or Tender.

4 DEFINITIONS AND REGULATIONS

- 4.1.1 The Technical Definitions are as given in the various parts of the relevant Standards.
- 4.1.2 Wherever reference is made to a British Standard (BS) a British Standard Institution recognised equivalent European Standard would also comply. Each type of equipment/material selected shall comply fully with either the BS or the European Standard.
- 4.1.3 Carry out the complete design and/or installation of Electrical Services described in the Specification and on the drawings in accordance with all relevant/current British Statutory Instruments, National and Local Regulations, British Standard Specifications, British Standards Codes of Practice, trade custom and practice
- 4.1.4 The Electricity at Work Regulations
- 4.1.5 Standards which must be satisfied include, but are not limited to;
- 4.1.6 Provision and use of work equipment Regulations (PUWER)
- 4.1.7 Health and Safety at Work Act
- 4.1.8 European Machinery Directive
- 4.1.9 Low Voltage Directive
- 4.1.10 EMC Directive
- 4.1.11 All Equipment is to carry the appropriate CE marking. Certificates of Conformity and Incorporation, demonstrating compliance, are to be issued upon request.

1.1. City University Site Safety Standards and Regulations

- 4.2.1 Carry out all design and installation of electrical works at City University establishments and buildings in strict accordance with all current City University site safety standards and regulations, including:-
- 4.2.2 Working regulations for contractors at the City University Site.
- 4.2.3 Supplementary safety and security requirements for contractors.
- 4.2.4 Electrical Safe Working.
- 4.2.5 Determine at the time of commencement for all particular projects, the current City University Health and Safety Standards and Regulations. Do not progress/carry out any design and/or installations without having full knowledge and awareness of all available health and safety documentation.

1.2. Safety Access for Plant Installation/Removal

- 4.1.12 Ensure before work is put in hand and orders are placed for any electrical plant or equipment, that each item can be safely admitted to its allotted position and installed in such a way together with all other



services, and that it can be replaced with similar replacement equipment at some future date, in strict compliance with all health and safety requirements.

- 4.1.13 Demonstrate that plant and equipment can be safely removed and replaced, using the same materials. Ensure all plant and equipment can be readily maintained in position, unless specifically agreed, in writing, with City University Operations Department in a particular case, when maintenance after removal would be accepted.

1.3. Maintenance

- 4.1.14 Give proper consideration to future safe maintenance and operation of the electrical plant and equipment. Include for component parts as are provided by the manufacturer of equipment and plant for this purpose. Include for such items as cleaning and access for testing and adjustment.
- 4.1.15 Ensure the above covers the installation of equipment to give ease of subsequent safe removal of electric motors, switchgear, batteries, or other electrical equipment etc. and of any other electrical item to which it may be reasonably anticipated that maintenance would apply.
- 4.1.16 Describe any deviation or special requirements in separate documents and appendices, when necessary and applicable.
- 4.1.17 Notify City University Operations Department of any revisions or additions to the foregoing, as they are published during the design or installation of the works. City University Operations Department will give appropriate instruction in each case.
- 4.1.18 Relevant Standards referred to in this Specification, apply to all those applicable to the works detailed on the drawings and in the Particular Project Specification.

1.4. Isolation of Plant and Machinery

- 4.1.19 City University Operations Department operates a 'Lock Off' policy using a combination of personal padlocks, group locks and callipers to ensure safe isolation of plant before work is carried out.
- 4.1.20 All isolators installed must be suitable for this purpose and be clearly marked

"SUITABLE FOR LOCKOFF"

5 ELECTRICITY SUPPLY

- 5.1 The secondary and final electricity distribution systems of each site is 400V/230V (+10% -6%) 50Hz 3-phase, 4-wire unless detailed otherwise in the Specification. The fault level at the origin, the earth-loop impedance external to the installation, the size and rating of the over current device at the origin, and the method of earthing to be used in the design or installation, may be given in the Specification and/or indicated on the drawings for reference only. Determine the particular installation requirements with City University Operations Department or by application to the DNO where they cannot be determined by calculation.
- 5.2 Unless confirmed otherwise by City University Operations Department the following system parameters are those applicable to the City University site and are to be applied in the design of the installation of the various supply voltages detailed below:-

The DNO supplies are

HV Distribution From DNO

11,000 volts

3 phase, 3 wire, 50Hz

Design Fault Levels - Symmetrical fault level 13.1kA

With the exception of CU HV systems, system neutral earthed by DNO either solidly or via current limiting resistance. Asymmetrical fault level to be obtained from PES.

LV Distribution From DNO

400 volts

3 phase, 4 wire, 50Hz

Design Fault Level - 50kA for 3 seconds

System neutral solidly earthed.

1.5. Low Voltage Supplies

- 4.1.21 Reception areas lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase.
- 4.1.22 Lecture Theatres and Laboratories lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase. Other socket outlets to suit the room use.
- 4.1.23 Classrooms Lighting and sockets outlets - 230Vac and 110Vac, 1 phase, 50Hz, all on the same phase.
- 4.1.24 Store rooms lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase.



- 4.1.25 Kitchens power system to suit installation, lighting and socket outlets 230Vac The lighting and 230Vac sockets should be on the same phase if possible.
- 4.1.26 Toilets and showers lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase.
- 4.1.27 Corridors lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase.
- 4.1.28 Staircases lighting and socket outlets 230Vac. The lighting and sockets should be on the same phase.
- 4.1.29 Switchrooms and sub-stations 230Vac sockets outlets 230Vac 110Vac and 400Vac TPN as required. The lighting and 230Vac sockets should be on the same phase if possible, the distribution board supplying the lighting and sockets should have a dual supply; one from another switchboard via an automatic change-over.
- 4.1.30 Plant power for MCCs 400Vac three phase with no neutral
- 4.1.31 Plant power via distribution boards 400/230Vac TPN/SPN
- 4.1.32 Plant rooms lighting 230Vac sockets outlets 230Vac 110Vac and 400Vac TPN as required. The lighting and 230Vac sockets should be on the same phase if possible.
- 4.1.33 Switchgear - Tripping and Closing Supplies 48Vdc (nominal) battery supply
- 4.1.34 SCADA system network components, field components and interface 24Vdc (regulated) computers and monitors 230Vac via UPS.
- 4.1.35 Power outlets above 13A single phase for plant and equipment in all areas shall generally be as MK Commando with local isolator and lock off. Outlets shall be specific for the plant or equipment. Therefore single phase equipment shall be fed from single phase outlets and three phase equipment from three phase outlets. Use of three phase outlets to supply single phase loads is prohibited.

1.6. Portable Power Tools

- 4.1.36 Electrically operated power tools will be suitable for 110V AC, or lower voltage. Each item of equipment will display a label stating date tested and tester's initials, in compliance with the Portable Appliance Testing Guidance Notes issued by the Health and Safety Executive.



5 DESIGN CRITERIA

6.1.1 Determine the design criteria for each project in conjunction with City University Operations Department.

6.2 AMTECH Electrical Design Software

- 6.2.1 City University Operations Department uses the 'AMTECH' suite of electrical design software. Designs must be submitted suitable for use with the Amtech software. Submissions must include single line diagrams of the installation covered by the calculations.
- 6.2.2 The main distribution schematic diagram and design drawings for each installation indicates the design criteria applicable at the time of tender.
- 6.2.3 Do not make change to the design and/or installation which invalidates the design values without written agreement from City University Operations Department
- 6.2.4 The design documentation will form the basis for comparison with measured results obtained during the testing and commissioning phase of the installation. At the outset of the Contract, all values indicated on the design and tender drawings shall have measured results inserted in the spaces provided. This is stressed so that measurements are taken before installation proceeds to a point beyond which insufficient access and, in the case of partially handed over areas, safe working practice and disruption to City University Operations Department preclude such actions.
- 6.2.5 Prior to commencing design or installation, show details of design, and/or installation working details where applicable, and check all measurements and work to particular project detail plans to verify dimensions, positions, etc. Agree all positions with City University Operations Department.

6.3 Energy Conservation

- 6.3.1 The design shall fully comply with the requirements of the building regulations for energy conservation.
- 6.3.2 City University requires its M&E installations to reflect current best practice regarding control and energy use. The overall expectation is that an area will use less energy after a refit than before.

6.4 Discrimination

6.4.1 The designer shall ensure proper discrimination at all parts of the system. The following table indicates minimum device sizes to achieve this.

Distribution Board Data			MCCB Data				
Max MCB rating	DB Maximum Demand	DB incomer rating	MCCB type	MicroLogic 2.2 rating	long time protection		short time protection
				In	I _o	I _r	I _{sd}
20A	50A	125A	NSX160	160A	63A	1	7
20A	65A	125A	NSX160	160A	90A	0.9	5
20A	80A	125A	NSX160	160A	100A	1	4
20A	100A	125A	NSX160	160A	125A	1	4
20A	125A	250A	NSX250	250A	160A	0.98	3
20A	150A	250A	NSX250	250A	200A	0.94	3
20A	175A	250A	NSX250	250A	225A	0.97	2
20A	200A	250A	NSX250	250A	250A	1	2
20A	225A	250A	NSX250	250A	250A	1	2
20A	250A	250A	NSX250	250A	250A	1	2

7 STANDARD OF MATERIALS / APPROVALS

- 7.1.1 All materials and components for incorporation into the works must be new and unused except as necessary by the manufacturer in their quality control procedures.
- 7.1.2 Execute the works with the materials indicated in the Specification. The design and/or tender must include for all makes of materials and components specified by City University Operations Department, but alternative makes of equal quality may subsequently be offered for consideration by City University Operations Department. Only use alternatives upon receipt of written instructions from City University Operations Department. Where materials and components are not specifically described, they are to be the best of their kind and, if required, submit samples and drawings of such materials or components to City University Operations Department for comment.
- 7.1.3 Use only equipment, materials and/or components of preferred or approved manufacturers specified by City University Operations Department. Refer to City University Operations Department lists and/or schedules of preferred installers/manufacturers prior to commencing design and/or tender/installation.
- 7.1.4 Notify City University Operations Department of any revisions or additions to the foregoing as they are published during the design and/or installation of the works. City University Operations Department will give appropriate instruction in each case.
- 7.1.5 City University Operations Department have the right of inspection of all works on site, and will reject any materials which are unsatisfactory due to poor workmanship, damage, or are not new, or failure to meet the requirements of the Project Brief, Design, Specification, drawings or tender documents.
- 7.1.6 Where the manufacture or assembly of plant or equipment takes place at a place other than a City University site then that place shall be deemed to be a City University site for purposes of inspection of the works.
- 7.1.7 Ensure that any tools which are required of a special nature for any equipment, etc., installed, are handed to City University Operations Department in a purpose designed box or receptacle.



8 SUITED KEY SYSTEM

- 8.1.1 Substations, compounds and switchrooms must be suitably locked to prevent unauthorised access. These areas must be kept locked or otherwise be attended by a CU approved AP(Electrical)

Function	Suite Ref	Typical Use
Authorised Persons for HV switching	KABA	11kV Plant Areas and below

9 HIGH VOLTAGE & LOW VOLTAGE SAFETY REGULATIONS

- 9.1.1 Ensure all persons operating or working on a HV System comply with City University Safety Rules for High Voltage Installations, or suitable approved equivalent i.e. Area Board Safety Rules.
- 9.1.2 Ensure Electrical Installer (or Specialist - if used) appoints fully trained 'Competent Persons' to supervise specified HV works and to receive 'permits to work' from an Authorised Person.
- 9.1.3 Ensure no work on HV or LV system is undertaken without first obtaining Permit to Work from City University Authorised Person.
- 9.1.4 Ensure no person enters a sub-station or high voltage enclosure unless accompanied by a City University Authorised Person or covered by a Permit-to-work issued by a City University Authorised Person.
- 9.1.5 High voltage is a potential normally exceeding 1000 volts ac but not normally exceeding 35000 volts ac.
- 9.1.6 Low voltage is a potential normally exceeding 50 volts but not exceeding 1000 volts ac or a potential exceeding 120 volts but not normally exceeding 1500 volts dc between conductors, or 600 volts ac or 900 volts dc between conductors and earth.
- 9.1.7 A sub-station is any enclosure, room, compound or area that contains equipment connected to a medium voltage supply.



10HV SUPPLY / DISTRIBUTION

10.1 PROTECTION AND METERING

Instrument Transformers

- 10.1.1.1 Provide current and voltage transformers of suitable class and accuracy to meet the specified/intended duty. Ensure the rated VA output is suitable for the type and magnitude of the connected burden.
- 10.1.1.2 Ensure current transformers for metering and control purposes are of minimum accuracies as follows:
 - 10.1.1.3 For revenue metering class 0.5,
 - 10.1.1.4 For other metering and transducers class 0.5,
 - 10.1.1.5 For instruments class 1.0 class
- 10.1.2 Ensure the accuracy limit factor for P5 and P10 CT's is appropriate for the protection scheme and greater than the highest available setting of any instantaneous element. Ensure the 'knee' point voltage of Class X CT's is sufficient for correct operation of the protection scheme and can maintain stability for 'through fault' conditions. Knee point calculations to be provided.
- 10.1.3 Do not insert isolating contacts in circuits between CTs and protective devices.
- 10.1.4 Provide CT test terminals that allow the CTs to be short circuited whilst simultaneously allowing secondary injection testing of the instruments or protection relays.
- 10.1.5 Ensure the removal of a protection relay from its case will 'short circuit' the connected CTs and that the removal of the relay does not cause the tripping circuits to activate.
- 10.1.6 Ensure all CT ratings, ratios, types and classes etc. are identified internal and external to the CT chamber on all equipment.

10.2 Metering

- 10.2.1 Ensure all meters are mounted between 1200mm and 1500mm above finished floor level.
- 10.2.2 Ensure all indicating instruments are of an approved manufacture and size to conform with the relevant Standard. Ensure the markings on the dials include the scale markings, the instrument transformer ratio and British Standard grading.
- 10.2.3 Ensure all instruments are:-
 - Flush mounted
 - Back connected
 - Provided with means for zero adjustment



- Metric fixings
- Minimal terminal size of M4

- 10.2.4 Use ammeters complying, where appropriate, with the relevant Standards, Long Scale Class Index 1.5, of moving iron type with external zero adjustment, flush mounting housed in pressed steel or plastic case with escutcheon plate, finished matt black. Use instruments of compatible appearance, size and finish, mounted as near as possible to associated equipment. Shroud all instrument terminals. Use dials of 96mm minimum square.
- 10.2.5 Allow for ranges covering zero to 125% of circuit switch rating, but verify ranges prior to ordering switchpanel.
- 10.2.6 11kV switchgear panels 96mm.
- 10.2.7 LV incomers and interconnectors 96mm
- 10.2.8 Outgoing MCCBs 72mm or 48mm by agreement.
- 10.2.9 On starters 48mm.
- 10.2.10 Connect ammeters, in phase L2 unless a selector switch is specified.
- 10.2.11 Ensure that selector switches for ammeters are of the 5-position type including OFF position to give the values in each phase and in the neutral conductor.
- 10.2.12 Scale voltmeters so that the normal reading, which is marked with a red line, appears on 2/3 full scale deflection. Provide selector switch if required.
- 10.2.13 Ensure all voltage connections to meters are individually fused and CT connections are made through shorting link terminals, such that meters can be replaced or the CT's and meters may be tested without disruption to supply.
- 10.2.14 House instruments associated with switchgear in separate compartments.
- 10.2.15 Ensure protection and metering to high voltage equipment is in accordance with the particular project requirements and agreed by City University Operations Department.

11 HV EQUIPMENT

- 11.1.1 Design and install all HV switchgear and distribution equipment within separate switchrooms/areas allocated for each particular project. Agree all requirements and locations with City University.
- 11.1.2 Provide for equipment types, sizes, and specifications to be satisfactorily accommodated in each HV switchroom with regard for overall dimensions, clearances for safety, access and maintenance, weights, environmental factors and operating conditions etc.
- 11.1.3 Locate sub-stations as near as possible to the load centre.
- 11.1.4 Ensure the sub-station and supply and extract air inlets and outlets are sited to avoid dust laden air and water penetration.
- 11.1.5 Provide ease of access for personnel and equipment, and space for extension.
- 11.1.6 Arrange the size of sub-station building to provide space for a minimum extension of one tier/unit of HV switchgear on either end of the HV switchboard.
- 11.1.7 Provide a minimum clearance of 1000mm at either end of the switchboard, after allowing for future extension.
- 11.1.8 Ensure the minimum distance between the rear of the HV equipment and the wall is 1000mm in excess of the distance required to open any hinged panels.
- 11.1.9 Allow sufficient space for withdrawal of any portion of the equipment to its fullest extent plus an access clearance of 1000mm, minimum.
- 11.1.10 Switchboards shall be suitable for installation on a floor that is flat and level with a tolerance of $\pm 1/2^{\circ}$ from absolute level with a flatness of ± 3 mm over the area occupied by the switchboard.
- 11.1.11 Provide the manufacturers proprietary lifting trolley, where applicable for any switchboard with withdrawable or demountable circuit breakers.
- 11.1.12 For internal trenches in sub-stations form cable trenches from concrete or brick and design such that the recommended minimum cable bending radii are not exceeded. Cover all trenches with easily handled sizes of GRP open grid covers complete with arrangements to allow lifting by one person.
- 11.1.13 Provide lighting to give a minimum of 350 lux. Arrange for 100% of normal lighting to be standby/emergency lighting for minimum 3 hours duration. Refer to Lighting Section of the Specification.
- 11.1.14 Provide minimum of two composite socket outlets for test equipment and portable tools per 100m² of floor area or part thereof. Refer to LV Power Section of the Specification.
- 11.1.15 Heating and ventilation requirements to HV switchrooms and/or transformer areas shall be determined for each particular project and agreed with City University Operations Department in writing.
- 11.1.16 Provide all sub-stations/switchrooms with the necessary signs, labels and notices. Provide for the following additional items in HV Switchrooms and adjacent to sub-station (where applicable):-



- 11.1.17 HV switchgear Traka box, complete with connections to Maintenance Office, hinged door and provision for securely containing HV system etc., padlock keys.
- 11.1.18 Ensure switchgear padlocks and keys as American Padlocks are provided marked as required by City University Operations Department.

12HV SWITCHGEAR

12.1 11kV Ring Main Units

12.1.1 Ensure construction of ring main units are in accordance with the requirements of relevant design standards and particular project requirements.

12.2 Merlin Gerin RN/T2 UK + VIP 300 Relay

12.2.1 Ensure ring main units are metal clad vacuum type switchgear of type and manufacture specified by City University Operations Department. Provide vacuum type switchgear where agreed with City University Operations Department. All HV switchgear to be suitable for connection onto the 11kV systems, shall have a short time rating as noted above.

12.2.2 Provide suitably sized earthing bar with earth straps to each cable gland position. Ensure every circuit, where applicable, is equipped with a fully rated integral circuit earthing device.

12.2.3 Ensure design of all cable boxes are for dry type air clearance terminations and provided with suitable heat shrink termination kits and cable gland.

12.2.4 Provide padlocks and keys to all busbar shutters, operating levers and mechanisms required for correct and safe operation of all sections of high voltage switchgear, including safety isolation of voltage transformer and associated facilities.

12.2.5 Provide anti-condensation heaters complete with on/off switch and fuses.

12.2.6 Provide sufficient auxiliary contacts and local SCADA equipment for status indication via the City University Operations Department HV SCADA network.

12.2.7 Check all switchgear ratings, protection relays and instrumentation for each particular project. Agree with City University Operations Department.

12.2.8 Determine final specification and selection of ring main units with City University Operations Department.

12.3 HV Composite Switchboards

12.3.1 Ensure specification for 11kV switchboards generally comply with the Specification and particular project requirements.

12.3.2 Determine final specification and selection of ring main units with City University Operations Department.

13 TRANSFORMERS

13.1 General

- 13.1.1 Ensure transformer construction is in accordance with the requirements of relevant design standards and detailed in the Specification.
- 13.1.2 Determine requirements for design/installation of dry type or fluid immersed type transformers for each particular project.

Transformer Type	Use
Dry	Indoors integral to or adjacent to main LV switchboard
Fluid immersed transformers	Outdoors, free standing or forming unit package with HV switchgear and/or LV feeder pillar Bunded to ensure no loss of filling medium to drains. Blind sump facility for pumping surface water to drain

- 13.1.3 Agree the nominal transformer rating, final selection and type with City University Operations Department in conjunction with the particular project design requirements and the site infrastructure requirements.
- 13.1.4 Ensure all internal monitoring equipment such as temperature sensors are wired to an external adaptable box on the transformer containing din rail mounted terminals, clearly labelled.

13.2 Fluid Immersed Transformers

- 13.2.1 Provide outdoor fluid immersed transformers to generally comply with the following, where specified:-

Mounting	Ground.
Location	Outdoor
Cooling	Natural with fixed plates radiators
Fluid medium	MIDEL 7131 Fluid
Winding	Double. (Impulse withstand 75kV peak @ 11kV)
Core	Cold rolled grain orientated sheet steel
Manufactured to	BSEN 60076
Phases	Three
Frequency	50 Hertz
Impedance (%)	Determined with City University Operations Department, for particular project
Rating	As indicated for the particular project design requirements
Vector group	Dyn
Voltage ratio	11,000/417 (no load) volts between phases, at no load, 0.8p.f

Connections	Delta/star to Vector group reference Dyn 11
Adjustable tappings	2.5% and + 5% on HV

Tapping Control	Manually operated, off circuit tapping switch with indicator and padlock provided
HV Terminations	Direct busbar terminations to ring main HV Switchgear, where applicable, or by proprietary cable box suitable for air insulated terminations sized to accommodate specified cable types/sizes
LV Terminations	Direct busbar connections from transformer LV integral terminations to LV distribution fuse feeder pillar unit, where applicable, or by propriety cable box sized to accommodate specified cable types/sizes
Tank type	Welded steel
Tank Fittings	Lifting & jacking lugs, oil level gauge, filling hole, cover and drain/sampler valve, air vent plain pipe with silica-gel dehydration breather, thermometer pocket, thermometer, earthing terminal, rating and diagram plate, skid type underbase and axles with plain rollers
Temperature Indicator	Oil temperature and/or winding temperature indicator with pre-alarm and alarm contacts

Ensure transformer is delivered to site with first filling of fluid.



13.3 Dry Type Transformers

Mounting	In cubicle with access doors
Location	Indoor
Cooling	Air natural with facility to increase rating by converting to air forced
Winding material LV & MV	copper
Winding	Double. (Impulse withstand 75kV peak @ 11kV)
Core	Cold rolled grain orientated sheet steel
Manufactured to	BSEN 60076
Phases	Three
Frequency	50 Hertz
Impedance (%)	Determined with City University Operations Department, for particular project
Rating	As indicated for the particular project design requirements
Vector group	Dyn
Voltage ratio	11,000/417 (no load) volts between phases, at no load, 0.8p.f

Location	Internal IP32
Insulation	Cast resin reinforced
LV Connections	Bus-bars to ACB (in package switchboards)
Ambient Temp	40°C maximum
Construction	Transformer to be mounted on four, bidirectional rollers for removal from the cubicle. Steel floor tracks for roll out to be provided. Provide anti-vibration devices on rollers.
Cooling	Class AN (provide for capacity for future forced cooling)
Enclosure	Generally, as specified for LV switchboards BS4800 00 E 55 full gloss white.

13.3.1 Include ventilated sheet steel of zinc coated mild steel with epoxy powder coated paint finish. IP 32 protection. Hinged door for access and removal, with safety padlocking facility. Electrical door switch interlock with HV switchgear. Enclosure, integral with LV switchboard. Removal covers for access to tap changers. Transformer rating plate to be fixed to outside of enclosure.

13.3.2 Bus bars to be readily extendible for future panel extension.

13.3.3 Both the MV and LV winding to be resin encapsulated

14 SUB-STATION FEEDER PILLARS

14.1 General

- 14.1.1 Provide switched and fully insulated distribution MCCB feeder pillar unit from the Schneider range in accordance with the schedule of approved manufacturers, and the following requirements, and where specified for the particular project and agree with City University Operations Department.
- 14.1.2 IP54 weatherproof, vermin proof, ventilated ground mounted enclosure, flange connection to transformer where applicable, or separately mounted.
- 14.1.3 The normal arrangement to consist of an incoming MCCB for supplies up to and including 630A and an incoming ACB for supplies above 630A the circuit breaker to be rated to suit the connected transformer rating.
- 14.1.4 Digital pulse type KWHr electronic meter to incoming transformer supply, in accordance with the schedule of approved manufacturers.
- 14.1.5 Ammeter with selector switch.
- 14.1.6 Voltmeter with selector switch
- 14.1.7 Current transformers and potential fuses for all outgoing supply MCCB's. Provide all wiring, connection, terminals, shorting links and identification etc., suitable for remote metering connections.
- 14.1.8 Padlocking devices for the ACBs/MCCB's.
- 14.1.9 Accommodation for cable types, quantities and sizes indicated for the particular project.
- 14.1.10 Interior light (Internal), complete with door operated switch.
- 14.1.11 Socket outlet and RCD (internal).
- 14.1.12 Anti-condensation heater with thermostatic control.



15 PACKAGE SUB-STATIONS

15.1 General

- 15.1.1 Provide package sub-stations where required for the particular project requirements generally in accordance with the following:-
- 15.1.2 11,000/417V cast resin transformer, rated for the particular project, in accordance with the transformer section of this specification.
- 15.1.3 Provide outgoing ACB's, Bus-Section ACB, MCCB's and fused switches as indicated for each particular project. Provide an ACB removal trolley in the LV switchroom where applicable. Ensure all operating levers are padlockable.
- 15.1.4 Include multi-stage automatic power factor correction equipment built into a section of the package sub-station (operating on mains power conditions only). Ensure operation is fully monitored. Provide general alarm output to the SCADA in the event of an alarm condition.
- 15.1.5 Metering, incorporating SCADA monitoring, agreed with City University Operations Department for each particular project.
- 15.1.6 Include space for cubicle extension and physical provision to be maintained at either end to facilitate future addition of outgoing switches on the Essential or Non-Essential sections, as indicated in the Specification.
- 15.1.7 Provide package sub-station LV switchboards with top or bottom entry and exit with rear access cable boxes in accordance with the requirements of L.V. Supply section of the Specification.
- 15.1.8 Provide SCADA indication of the following package sub-station LV switchboard information relating to the particular project via N/O, volt free contacts.
 - Transformer common alarm.
 - Mains failed.
 - Power factor correction common alarm.
 - Pulsed KWHr metering.
- 15.1.9 Provide a physically protected, manual push button to remotely trip the HV switchgear.

16 TRIPPING / CLOSING SUPPLIES

16.1 General

- 16.1.1 Ensure where switchgear trip batteries are required, vented nickel cadmium, long life, maintenance free units are provided. Provide integral battery charger, with automatic regulation to keep the battery charge maintained without overcharging.
- 16.1.2 Ensure on discharge, the battery charger is capable of fully recharging the batteries within eight hours. Contain batteries and charger in a steel wall mounting or floor standing cubicle with suitable access covers for battery inspection. Provide fault indication for charge failure, low volts, etc., with contacts available for remote alarm indication. Carry out wiring of switchgear trip circuits in LS0H/LS0H cable.

16.2 Capacity of tripping supplies

- 16.2.1 Batteries shall have a capacity sufficient for tripping all the switchgear trip units served, simultaneously, at least four times in succession without recharging plus any standing load of the switchgear.
- 16.2.2 On installations where protection equipment consumes a standing load, the capacity of the system must be rated to operate all of the switchgear trip units served, simultaneously, at least four times in succession after a minimum mains failure period of 12 hours.

17LV SUPPLY / DISTRIBUTION PROTECTION AND METERING

17.1 Instrument Transformers

- 17.1.1 Provide current and voltage transformers of suitable class and accuracy to meet the specified/intended duty. Ensure the rated VA output is suitable for the type and magnitude of the connected burden.
- 17.1.2 Ensure current transformers for metering and control purposes are of minimum accuracy Class 0.5.
- 17.1.3 Ensure the accuracy limit factor for P5 and P10 CT's is appropriate for the protection scheme and greater than the highest available setting of any instantaneous element. Ensure the 'knee' point voltage of Class X CT's is sufficient for correct operation of the protection scheme and can maintain stability for 'through fault' conditions. Knee point calculations shall be provided.
- 17.1.4 Do not insert isolating contacts in circuits between CTs and protective devices.
- 17.1.5 Provide CT test terminals that allow the CTs to be short circuited whilst simultaneously allowing secondary injection testing of the instruments or protection relays.
- 17.1.6 Ensure the removal of a protection relay from its case will 'short circuit' the connected CTs and that the removal of the relay does not cause the tripping circuits to activate.
- 17.1.7 Ensure all CT ratings, ratios, types and classes etc. are identified internal and external to the CT chamber on all equipment.

17.2 Metering

- 17.2.1 Ensure all indicating instruments are of an approved manufacture and size to conform with the relevant Standard. Ensure the markings on the dials include the scale markings the instrument transformer ratio and British Standard grading.
- 17.2.2 Ensure all instruments are:-
 - Flush mounted
 - Back connected c/w terminal shrouds or covers.
 - Provided with means for zero adjustment
 - Metric fixings
 - Minimal terminal size of M4
- 17.2.3 Use ammeters complying, where appropriate, with the relevant Standards, Class Index as detailed above, of moving iron type with external zero adjustment, flush mounting housed in pressed steel or plastic case with escutcheon plate, finished matt black.



- 17.2.4 Use instruments of compatible appearance, size and finish, mounted as near as possible to associated equipment. Shroud all instrument terminals. Use dials of sizes as noted above. Allow for ranges covering zero to 125% of circuit switch rating, but verify ranges prior to ordering switchpanel.
- 17.2.5 Connect ammeters, in phase L2 unless a selector switch is specified. Ensure that selector switches for ammeters are of the 5-position type including OFF position to give the values in each phase and in the neutral conductor. Scale voltmeters so that the normal reading, which is marked with a red line, appears on 2/3 full scale deflection. Provide selector switch if required.
- 17.2.6 Ensure all voltage connections to meters are individually fused and CT connections are made through shorting link terminals, such that meters can be replaced without disruption to supply. House instruments associated with switchgear in separate compartments.

17.3 Tariff Metering

- 17.3.1 In general each main LV incoming switchboard/MCC serving a building or area is to be provided with Polyphase multi-parameter electricity meter complying with Ofgem requirements for the incoming supply, with digital output for connection to SCADA system and direct LED readout. The unit is to be housed in a separate compartment, containing voltage fuses, CT isolating terminals/links, and any associated equipment.
- 17.3.2 Ensure protection and metering to low voltage equipment is in accordance with the particular project requirements and agreed by City University Operations Department.

18 LV SWITCHROOMS

18.1 General

- 18.1.1 Ensure the layout and arrangement for each LV switchroom complies with all relevant Regulations, Standards and Codes etc.
- 18.1.2 Provide for equipment types, sizes, and specifications to be satisfactorily accommodated in each LV switchroom with regard for overall dimensions, clearances for safety and maintenance, weights, environmental factors and operating conditions etc.
- 18.1.3 Size all switchrooms to also include space for future switchgear and equipment extensions.
- 18.1.4 Ensure general requirements for sub-stations, switchrooms and transformer bays, as indicated in the HV Supply section of the Specification are incorporated, where applicable, in the LV switchroom. Agree all requirements with City University Operations Department.



19 LV SWITCHBOARDS

19.1 General

- 19.1.1 All switchgear supplied in accordance with this section of the specification to be Fully Type Tested Assemblies (TTA) to BS EN 60439 complying with the recommendations of the relevant Design Standards, and particular project requirements.
- 19.1.2 Standards which must be satisfied include;
- 19.1.2.1 The Electricity at Work Regulations
 - 19.1.2.2 Provision and use of work equipment Regulations (PUWER)
 - 19.1.2.3 Health and Safety at Work Act
 - 19.1.2.4 European Machinery Directive
 - 19.1.2.5 Low Voltage Directive
 - 19.1.2.6 EMC Directive
- 19.1.3 Equipment is to carry the appropriate CE marking. Certificates of Conformity and Incorporation, demonstrating compliance, are to be issued upon request.

19.2 Enclosure

- 19.2.1 The high grade steel enclosure to be a minimum of 2mm thick and be machine folded/welded or bolted modules.
- 19.2.2 Suitable separation by internal rigid barriers/partitions to meet the requirements of Form 4 type 7 construction unless agreed otherwise by the City University Operations Department.
- 19.2.3 Connections from the busbars to the live side of functional units to be adequately shrouded/separated in the associated compartment.
- 19.2.4 Arrange adequate accommodation for outgoing circuits, sufficiently separated from interconnections etc., and designed in such a manner that connections can be made and maintenance carried out in safety on any piece of equipment without disturbance to another energised functional unit.
- 19.2.5 Removal of any covers to facilitate individual cabling of outgoing circuits, will not expose live parts.
- 19.2.6 Cubicle doors shall open to 120° and be hinged and be held level when both open and closed
- 19.2.7 Full segregation to be provided between low voltages and extra low voltages (as defined in IEE or IET wiring regulations) and in particular between mains voltages, control voltages and equipment. Terminals above 50V will have clear covers marked with the terminal voltage.

19.3 IEC 1641 Guide for testing under conditions of arcing due to internal fault

- 19.3.1 Compartment doors/complete assembly to be constructed to withstand the expansion of gases due to short circuits and to ensure venting of such gases does not endanger personnel and adjacent compartments. Panels to be complete with a 50mm high, minimum, removable metal plinth.
- 19.3.2 Switchboards shall be suitable for installation on a floor that is flat and level with a tolerance of $\pm 1/2^\circ$ from absolute level with a flatness of $\pm 3\text{mm}$ over the area occupied by the switchboard.
- 19.3.3 Panels to be readily extendible from both ends and include spare panels as detailed in particular project specification.
- 19.3.4 Restrict equipment mounted on doors to instruments, control switches, switchgear relays, and switch operating handles.
- 19.3.5 Divide each section of main switchpanel, into compartments on modular basis, to ensure future alterations and/or additions of equipment within the switchpanel can be accomplished without difficulty. (i.e. bolted removable divisions not welded).
- 19.3.6 Doors to be lockable using a special tool i.e. triangular type cam lock.
- 19.3.7 The degree of protection to be selected for the envisaged environmental conditions and minimum IP31 unless otherwise stated on the enquiry.

19.4 Busbars

- 19.4.1 All busbars both main and subsidiary to be manufactured from hard drawn high conductivity copper. The entire busbar system is to be rated to withstand the short circuit time current specified and be fully type tested by an approved body i.e. ASTA.
- 19.4.2 Provide neutral busbars of same rating as phase busbars. The busbars to be enclosed in a separate earthed metal chamber, with the main busbar located at the top of the switchboard. All busbar joint surfaces to be tinned or plated and all joints bolted together. Busbar identification, i.e. colour bands, to be provided at regular visible positions.
- 19.4.3 Consideration to be given to fully insulated busbar assemblies' dependant on location/environment and integrity of supply requirements.
- 19.4.4 Ensure connections between busbars and all switchgear are adequately rated for load and fault current. All connections from the busbar system to protective device should be made in solid copper, where cable connections are made the cable is to be kept as short as possible. Connection from busbar to protection device will require tests carried out to EN 60439-1 : 1994
- 19.4.5 Ensure all penetrations of live busbars into outgoing circuit compartments or cable chambers are fully shrouded. Shroud and insulate all live parts, accessible or passing through various compartments.

19.5 Cabling

- 19.5.1 The small wiring to be single core 600/1000V grade LS0H insulated stranded copper conductor of 2.5 mm² minimum cross section, to BS 6231, where practical.

19.5.2 Fitted with interlocking numbered ferrules and is to be bunched and cleated or run in LSOH trunking.

LV Switchboard Cable colours	
Mains voltage circuits (230V/400)	
Phase 1	Brown L1
Phase 2	Black L2
Phase 3	Grey L3
Neutral	Blue N
Control Circuits:	
110Vac Live	Yellow/Brown
110Vac Neutral	Yellow/Blue
24Vac Live	White/Brown
24Vac Neutral	White/Blue
+ 48Vdc	Orange/Red
- 48Vdc	Orange/Black
+ 24Vdc	White/Red
- 24Vdc	White/Black
CT wiring phase L1	Violet/Brown
CT wiring phase L2	Violet/Black
CT wiring phase L3	Violet/Grey
CT wiring neutral	Violet/Blue
Earth Conductors	Green/Yellow striped

19.6 BS7671 Wiring Colour Change – Panel to include a legend to identify colours used.

- 19.6.1 Each wire to be clearly identified by a ferrule at each end, permanently numbered in accordance with the schematic control and wiring diagrams. The ferrules may be colour coded or have black numbers on a white background. Ferrules are to be used that completely encircle the conductor or a rigid supporting bar permanently attached to the conductor. Ferrules to read from the termination outwards. Adhesive markers are not permitted.
- 19.6.2 Bushes shall be fitted where cables pass through metal partitions.
- 19.6.3 Auxiliary and control wiring is not to pass through the busbar chamber, without secondary protection.

- 19.6.4 Extra low voltage control wiring must be segregated from wiring at higher voltage.
- 19.6.5 Provide removable, gland plates on external surface of each switchpanel section, sized to suit the specified cables and bonded to main earth bar.
- 19.6.6 Where single core main cables are used the gland plates are to be of a nonferrous construction.
- 19.6.7 Provide unrestricted access to cable routes and terminations and facilities for firmly supporting cables within cubicle type switchboard, with cable sizes and types indicated for the particular project.
- 19.6.8 Ensure all cable compartments are sized to meet specification requirements and for full cabling/termination access.
- 19.6.9 Provide terminations suitable for copper cables. Fully rate neutral terminations as phase terminals. Fix, rigidly, all terminations.
- 19.6.10 All power, control and signal wires to be terminated using compression type crimps.
- 19.6.11 Terminals for power wiring to be of the clamp or stud type. Terminals for control wiring to be of the pressure clamp type or screw type. Pinch screw terminals, where the screw bears directly onto the conductor, are not permitted.
- 19.6.12 All wiring to be connected to the same side of an outgoing terminal block, the other side is only to be used for external wiring. Not more than two wires shall be connected to each terminal. Proprietary type cross-connecting links are to be used where conductors are to be commoned together.
- 19.6.13 Use Klippon type SAK, or equal, for auxiliary circuit terminations. Physically separate terminals for extra low voltage from those for low voltage circuits. Provide insulating shrouds over terminals, labelled to indicate voltage class, where appropriate.
- 19.6.14 Clearly number or identify all terminals.
- 19.6.15 Provide safety screens and warning labels to all terminals which may be live after switching OFF main incoming unit(s).
- 19.6.16 Use design and siting of fuse carriers to prevent accidental contact with 'live' metal whilst the fuse carrier is being inserted or withdrawn from the fuse base. All fuse carriers are to be clearly labelled with function and fuse rating.
- 19.6.17 Ensure adequate shrouding of the fuse base contacts to prevent accidental contact with 'live' metal when the fuse carriers have been withdrawn.

19.7 Earthing

- 19.7.1 There is to be good earth continuity between all non-current carrying metal parts.
- 19.7.2 Supply each panel with a suitably sized earth bar installed throughout the full length of the panel. Size with copper earth conductor in accordance with the relevant standards for the fault level, subject to a minimum of 25 x 3 mm.



- 19.7.3 Bond all equipment which is not specially earthed to main earth conductor by means of earth tapes sized in accordance with the relevant standards. Provide bonding connections to each item of switchgear, and cable gland plates.
- 19.7.4 Any hinged doors and removal covers to be earthed by a separate flexible earth conductor.
- 19.7.5 The earth bar shall be drilled to accommodate all the protective conductors and the main incoming supply cable earth.

19.8 Labelling

- 19.8.1 A Traffolyte or equivalent designation label having a black legend on a white background to be fitted to:
- 19.8.2 Each cubicle detailing compartment number, CU designation, rating of device and number of poles or other details of cubicle contents such as metering, name of service. Font to be Tahoma minimum 3.5mm high. All to be agreed in advance with City University Operations Department. No other information shall be included on the label.
- 19.8.3 Labels that advertise persons, companies, services or any information not required in this specification shall not be affixed to any part of the switchboard.

19.9 Circuits

- 19.9.1 All circuits, selector switches, indicating lights, push buttons, etc.

19.10 Warning

- 19.10.1 All covers doors and complete assembly to be provided with suitable labelling to comply with Health and Safety requirements, colour coded to suit.

19.11 Cubicle Door

- 19.11.1 Each compartment will have a reference number, positioned in one corner of the door, on the outside. The reference number will be in two parts with a letter to designate the relevant column followed by a number to designate the position of the compartment in the column starting at the top. i.e. compartment B3 would be the third compartment from the top of the second column starting from the left.

19.12 Main Label

- 19.12.1 A main label in accordance with design standards. Detailing as a minimum the manufacturers name and serial number, year of manufacture, voltage rating, busbar current rating, Fault Level, IP rating and switchboard references.
- 19.12.2 Issue full label schedule for agreement prior to manufacture.

19.13 Incoming and Outgoing Devices

- 19.13.1 Ensure short circuit ratings, current ratings, number of poles and fusing arrangements etc. are as indicated on the particular project drawings or in the specification.
- 19.13.2 Ensure that all switching devices are suitable for padlocking in the 'OFF' position. The switch cover or door to be interlocked with operating mechanism such that it cannot be opened with the switch in the 'ON' position, or the locked 'OFF' position.
- 19.13.3 Use switches of manual independent type not allowing switch to be closed unintentionally e.g. when changing fuses.
- 19.13.4 Provide positive drive ON/OFF indicators, and ensure ON and OFF positions of switch operating handles are arranged in a manner in which handles when operated, are identical for all fuse switches and switches on panel.-
- 19.13.5 Rate switches for uninterrupted duty, fault making and load breaking capacity without damage or reduction in service capacity thereafter.
- 19.13.6 Rate fully all neutral terminals to match phases.
- 19.13.7 Shroud all live cable terminals and fixed contacts with insulating material to prevent accidental contact with live metal when the switch cover is opened.
- 19.13.8 Provide for making off the incoming cable directly at either the top or at the bottom of the isolator. Fully shield termination points to avoid accidental contact, and label shield to indicate danger.

19.14 Circuit Breakers

- 19.14.1 Circuit breakers to be two pole, or four pole either 'Air Circuit Breakers' or 'Moulded Case Circuit Breakers' as specified. The circuit breakers shall have the number of contacts equal to the number of wires in the supply that is four pole for three phase and neutral supplies, three pole for three phase supplies and two pole for single phase and neutral supplies unless specifically agreed in writing with City University operations Department. Fault rated to a minimum level equivalent to that of the busbar system.
- 19.14.2 The closing mechanism of ACBs to be 'manual spring' unless otherwise stated on the enquiry.
- 19.14.3 ACB's to be withdrawable type.
- 19.14.4 MCCB's to be fixed, plug-in or withdrawable. Suitable for the functions of isolation and switching; marked with the disconnecter symbol accordingly. They are to utilise a trip free mechanism and be capable of on site adaptation of auxiliaries and protective elements. All devices shall be installed so as to allow future replacement if the device fails, with electrical isolation only, no disassembly of the panel shall be required.

19.15 Fuse - Switch – Disconnector

- 19.15.1 Fuse switch equipment to be of the fault making, load breaking type. Fault rated to a minimum level equivalent to that of the busbar system and be fitted with HRC fuses to BS 88 and shall break all the conductors of the circuit.



19.15.2 Switch suitable for utilisation category AC23.

19.16 Switch Disconnectors

19.16.1 The switch is to be fault rated, to operate at full load , and capable of interrupting total stalled loads, safely and without damage and shall break all the conductors of the circuit.

19.16.2 Switch suitable for utilisation category AC23.

19.17 Protection and Metering Requirements

19.17.1 The specific requirements for protection and metering to be stated in the enquiry. Generally all loads rated at 60A or above shall be fitted with CT's in a separate compartment to allow metering to be fitted at a later date. A test block with CT shorting links shall be provided in a separate compartment.

20 UNIT TYPE SWITCHBOARDS

- 20.1.1 Ensure the panels consist of switchgear units and fuse gear specified together with all cable boxes, terminations, conduits and wiring interconnections, required for the particular project requirements.
- 20.1.2 Agree, prior to ordering, with City University Operations Department fault and voltage ratings.
- 20.1.3 Mount all switchgear and fuse gear on an angle iron framework within the dimensions of the space provided for the particular project.
- 20.1.4 Include for all necessary support steelwork to span trenches where unit-type switchboards are sited over formed floor trenches.
- 20.1.5 Provide all floor/wall fixings required.
- 20.1.6 Ensure the busbar chamber spans the whole length of the switchboard and is readily extendible. Ensure copper busbars are of the minimum rating of the main incoming switch, suitably colour coded both on the bars and on the chamber cover.
- 20.1.7 Ensure connections between busbars and respective switchgear and distribution gear are by copper bars, rods or copper cables suitably fixed with clamps and bolts.
- 20.1.8 Mount suitable cable trunking and matching steel cabinet on the frame to accommodate metering CT's and other equipment where required, or agreed with City University Operations Department.
- 20.1.9 Provide instrumentation where indicated for each particular project.
- 20.1.10 Ensure each unit switchboard is complete with Protective Conductors bonding all components as set out in the relevant Standards. Provide a main earth terminal.
- 20.1.11 Ensure no through wiring is provided in the unit type switchboard. Assemble all unit switchboards from one manufacturer's equipment with common finish.



21 LV BUSBAR INSTALLATION

- 21.1.1 Agree with City University Operations Department, LV busbar installation requirements for each particular project.
- 21.1.2 Internal rising busbars shall be of the Schneider Canalis type with full size internal neutral and earth conductors.
- 21.1.3 All tap off units shall be equipped with VIGI earth protection and minimum Micrologic 2.2 overloads.

22 DISTRIBUTION BOARDS - GENERAL

22.1 General

- 22.1.1 Locate distribution boards in one or more groups, subject to plant layout and electrical loading requirements.
- 22.1.2 Mount distribution boards so that they are readily accessible and fixed firmly to the building fabric by approved fixing, or to metal framework by nuts, bolts and washers, all in accordance with the Specification. All distribution boards must be mounted in accessible areas and to be accessible without use of access equipment. The top of distribution boards shall be no more than 1500mm AFFL unless agreed in writing by PAF operations. All distribution boards are to be fitted with locks supplied by City University Operations Department.
- 22.1.3 Distribution Boards shall be Schneider Acti 9 type.
- 22.1.4 Distribution boards shall be equipped with surge protection devices.
- 22.1.5 Mount power distribution boards supplying socket outlets in laboratory or workshop areas externally, near to the entrance of each lecture room or laboratory. Protect all laboratory final circuits with RCBO's rated at 30mA sensitivity. No more than six socket outlets are to be supplied by radial circuits thus protected.
- 22.1.6 Where power outlets other than 13A single phase are present, the power circuits supplying these must be protected by RCBO or Vigi and must be equipped with EPO buttons at agreed locations within the space. Resetting of the circuit after EPO operation must not be accessible to non-Operations staff.
- 22.1.7 Ensure all terminations are fully shrouded. Access to busbars and cabling terminals shall only be by removal of fixed screwed cover plates.
- 22.1.8 Provide distribution boards complete with lockable hinged front covers (side hinge only) to provide access to, fuses, MCBs and RCDs for maintenance and switching. Fix CU circuit charts inside each distribution board.
- 22.1.9 Ensure distribution boards shown without local isolating switches are supplied complete with integral two or four pole mains isolator with cable terminations sized to accommodate the specified supply cables.
- 22.1.10 Ensure that adequate provision is made within the distribution board to receive the specified cabling and that the boards are physically sized to suit the proposed installation location.
- 22.1.11 Ensure ingress protection is a minimum of IP31 rating and that all cable entries into the board maintain this protection rating.
- 22.1.12 Provide all distribution boards complete with fully rated neutral and earth termination with one neutral and earth connection for each single phase output distribution way.
- 22.1.13 Provide distribution boards with adequate earth termination facilities to accommodate the equipotential and supplementary earth requirements for each particular project.
- 22.1.14 Ensure all distribution boards are manufactured by an approved manufacturer and/or supplier, unless otherwise agreed by City University Operations Department.

22.1.15 The distribution boards to be provided with at least 20% spare capacity.

22.1.16 Distribution boards shall be equipped with extension chambers allowing installation of meters. The Contractor shall ensure that meters are connected to the SCADA system. Extension boxes shall have plain covers with no penetrations. Suitable CT's and shorting links shall be installed from the outset. Provide CT test terminals that allow the CTs to be short circuited whilst simultaneously allowing secondary injection testing of the instruments or protection relays.

22.1.15 Tenancy sub metering- • Automatic monitoring and targeting (AMT) equipment is installed. AMT equipment comprises meters, an automatic meter reading device and analytical software.

- The meter component is installed for each floor and each tenancy area within a floor for space heating and cooling, and domestic hot water.

22.2 HRC Distribution Boards

22.2.1 Generally HRC Distribution Boards shall not be installed without the express prior written consent of City University Operations Department, who have sole and absolute discretion to decline any proposal for such an installation.

22.2.2 Ensure these are minimum 400 volt rating with the number of ways and fuse ratings as shown on the project drawings and/or detailed in Particular Project Specification. Ensure they conform to the relevant Standards.

22.2.3 Ensure circuit protection is of the cartridge type complying to the relevant Standards with BS 88 HRC fuses.

22.2.4 Ensure in HRC distribution boards that the fuse carriers are withdrawable and the base contacts and terminals are shrouded.

22.3 MCB Distribution Boards

22.3.1 Ensure miniature circuit breaker boards are Schneider Acti 9c and comply with the relevant Standards. Supply complete with MCB's of the sizes detailed on the drawings / schedules and / or in the Particular Project Specification.

22.3.2 Ensure MCB's conform to the relevant Standards and of the type defined in the Particular Project Specification or drawings (e.g. type C unless prior written authorisation has been obtained.)

22.3.3 MCB's should have 'trip free' mechanisms and positive contact indication. The MCB dolly should be capable of being locked in the on or off position with a locking device. A minimum of two locking devices to be provided with each distribution board.

22.3.4 Use combined MCB/RCD units where required for each particular project, and ensure compliance with specification.

22.3.5 All MCB distribution boards shall have side hinged lockable doors. These are to accept standard CU DB lock mechanisms which will be fitted by City University Operations Department.



22.3.6 All new distribution board assemblies shall be supplied with one A9A26970 locking device and if RCBO's are used one A9A27049 locking device.

22.3.7 Blank ways shall be populated with SEA9BP blank pole.

23 POWER FACTOR CORRECTION EQUIPMENT

23.1 General

- 23.1.1 Ensure due consideration is given to the installation of power factor correction equipment for each new development.
- 23.1.2 In general, this will consist of each main incoming LV switchboard being provided with multi-stage automatic power factor equipment to provide correction from 0.80 lagging to a minimum of 0.95 lagging, for the full load capacity of the LV switchboard.
- 23.1.3 Alternatively, individual plant items can be fitted with PFC equipment. Where this is proposed such equipment must be clearly labelled and arrangements for safety discharge agreed with City University Operations Department.
- 23.1.4 Static PFC equipment may be considered in special cases.

23.2 Capacitors

- 23.2.1 Ensure that capacitors are suitable for operation on a 400V, 3-phase, 50Hz supply unless otherwise specified for the particular project.
- 23.2.2 Ensure each capacitor has over pressure operated disconnect fuse elements, in addition to standard overcurrent fuse protection.
- 23.2.3 Fit capacitors with an automatic discharge device to achieve full discharge (residual voltage less than 50V) within one minute after disconnection.

23.3 PFC unit construction

- 23.3.1 Ensure automatic power factor correction equipment, is contained within appropriate sheet steel enclosures and are of suitable ratings determined at the time of calculation and agreed with City University Operations Department.
- 23.3.2 Provide a Power Factor programmable microprocessor Control Relay Unit, complete with associated control equipment to automatically switch the optimum number of capacitor steps to maintain the specified corrected power factor.
- 23.3.3 Ensure that the control equipment provides the following facilities:-
 - 23.3.3.1.1 Automatic disconnection of all capacitors in the event of mains failure, with a two minute delay before re-connection.
 - 23.3.3.2 Target Power Factor setting adjustable from 0.8 inductive to unity.
 - 23.3.3.2.1 Time delay between switching of stages to ensure capacitors are sufficiently discharged before re-energisation and to prevent hunting.



- 23.3.3.3 Push button operated manual override incorporating time delay as above.
- 23.3.3.4 Adjustable switching programmes.
- 23.3.3.5 Incorporate normally open volt free contacts for SCADA indication for common alarm.
- 23.3.3.6 Visible LED type indication of capacitor stages.
- 23.3.4 Incorporate integral main 2 or 4 pole MCCB to power factor equipment.
- 23.3.5 Protect each capacitor stage with HRC fuses of current rating no less than 1.5 times rated capacity current. Ensure cables serving power factor correction equipment are sized and rated in accordance with the equipment manufacturer's recommendations for the capacitor rating. Include overload protection against harmonic currents, and select capacitors accordingly.
- 23.3.6 Ensure all capacitor control contactors are rated for its switching duty.
- 23.3.7 Ensure power factor equipment is automatically disconnected prior to the operation of standby generator(s).

24 INSTALLATION AND TESTING

24.1 General Installation

- 24.1.1 Main switchboard and MCC's, which are free-standing, to be positioned and fixed on level foundations and that all connections are tightened by a torque wrench following assembly.
- 24.1.2 Where equipment is not floor mounted assemble on a purpose made framework. This is to be fabricated from unistrut or equal and so designed as to enable all fixing lugs on equipment to be secured with nuts and bolts of appropriate size.
- 24.1.3 All joints to be accurately saw-cut, butt welded and ground as necessary to ensure a smooth face to the frame. Fixing lugs attached to the framework in readily accessible positions, for securing to the building structure.
- 24.1.4 All trunking and accessories to be of approved type and manufacture and the stipulations laid down in the section of the Specification on cable trunking to apply. All trunking and accessories shall be individually secured to the framework.
- 24.1.5 All connections between trunking and fuseboards, contactors, etc. to consist of flanged connectors.
- 24.1.6 Particular attention to be paid to ensure that connectors are completely free from jagged edges and projections likely to damage cables. Cableways between switching devices and trunking be shielded with thick paxolin sheet drilled to the exact size to receive outgoing cables.
- 24.1.7 Under no circumstances will open voids be allowed between this equipment.

24.2 Inspection and Testing

- 24.2.1 Equipment to be inspected and tested and, if required, facilities to be provided for witnessing final tests at works.

24.3 At Works

- 24.3.1 Inspection and tests to ensure equipment is operating functionally correctly. Test to include, as a minimum:-
 - 24.3.1.1 Check paint finish and physical arrangement of switchboard.
 - 24.3.1.2 Checking with compliance to drawings.
 - 24.3.1.3 Voltage withstand (Dielectric) test.
 - 24.3.1.4 Functional Tests on all devices.
 - 24.3.1.5 Injection tests on all meters and protection devices to prove operation.



24.4 At Site

24.4.1 If site testing/erection/commissioning is required this will be called for in the enquiry.

24.4.2 The manufacturer to provide a fully detailed test schedule.

24.4.3 After a switchboard has been erected and the busbars fitted and switchboard earth bar connected to the site earth all power devices shall be closed and subsequent to any insulation testing a high current milli-ohmmeter shall be used to measure the resistance of each pole of the incomer or incomers circuit breaker's external connections to every outgoing circuit breaker's external connections, the readings obtained shall be recorded.



ESSENTIAL SUPPLIES



25 STANDBY GENERATORS

- 25.1.1 Due consideration to be given for incorporating facilities for on-load testing, by provision of a fixed load bank or other means approved by City University Operations Department.
- 25.1.2 Determine emergency generator control and operation requirements with City University Operations Department for each particular project.
- 25.1.3 Notwithstanding the governing and voltage requirements laid down by the standards mentioned in this specification the overriding requirement is that the generating set or where multiple generators are installed generating sets shall under steady state conditions maintain the supply at 400Vac $\pm 1V$ 50Hz ± 0.125 Hz from 25% to 100% of the rated generator(s) output. The maximum temporary change of speed of a generator or suite of generators expressed as a percentage of the declared speed on any step change of 25% of the rated full load on and off shall not exceed 2.5%. The maximum recovery time for these conditions shall not exceed 2.5 seconds. The maximum temporary change of voltage of a generator or suite of generators expressed as a percentage of the declared voltage on any step change of 25% of the rated full load on and off of a generator or suite of generators shall not exceed 2%. The maximum recovery time for these conditions shall not exceed 0.5 seconds.
- 25.1.4 The output voltage imbalance, of a generator or suite of generators, when measured between any phase and neutral shall not exceed 6% when the load imbalance between any two phases is 20% of the load, with a power factor difference of 20%.

25.2 Controls and Interfaces

- 25.2.1 Provide the following operational facilities:-
- 25.2.2 Fully automatic starting on failure or reduction to adjustable value of between 80 and 100% (but normally set at 85%) of voltage of any one phase for adjustable period of 0-30 seconds, (but normally set at 10 seconds).
- 25.2.3 Sensing of reference voltage from remote source.
- 25.2.4 Key selectable manual or automatic restoration of normal supply after adjustable period of 0-240 minutes by use of timer which shall recycle sequence in event of subsequent failure during run-on time.

25.3 SCADA Indication

- 25.3.1.1 Provide series of normally open contacts in the control panel to provide separate SCADA indication for the following situations:-
- 25.3.1.2 Generator running.
- 25.3.1.3 Generator Circuit Breaker Open / Closed / Tripped
- 25.3.1.4 Generator on-load.
- 25.3.1.5 Generator common alarm.
- 25.3.1.6 Generator fuel low alarm.



25.3.1.7 Fusible link/fuel cut-off.

Mains Cables

25.3.2 Ensure the main auxiliary and earthing terminals of AC generators are adequate in size for the designed current to be carried, and properly secured, mounted and protected. Provide means for preventing the terminals from working loose after connections have been made.

25.3.3 Provide flexible single core cables with aluminium armour entering gland plates at insulated glands. Gland plates for single core cable entry to be of the non-magnetic metal or slotted and brazed steel type to prevent gland plate circulating currents.

25.3.4 Ensure AC generator cables and glands are of adequate load and fault current rating suitable to withstand the largest prospective fault current for the most onerous connection.

25.4 Protection Relays

25.4.1 Ensure electrical protection relays are of the highest quality and comply with the relevant British Standards. For simple arrangements, an electromechanical relay is suitable. For more complex arrangements, the more proven makes and designs of electromechanical and/or electronic (static) relays be chosen. Protection requirements must be agreed with City University Operations Department

25.4.2 The use of protective devices that can be programmed remotely or have their contacts programmed is prohibited as once the protection has been set there should be no reason for the either the settings or contact configuration to be changed.

25.5 Wiring

25.5.1 Ensure interconnecting wiring between control and indication equipment mounted on the diesel alternator set main framework has adequate protection against mechanical and oil damage. Wiring to be enclosed in screwed steel conduit or oil resistant cable. Flexible metal conduit and flexible wiring which provide a similar protection against mechanical damage should be used between rigid components and those that are subject to vibration whilst the set is running.

25.5.2 MICC cable must not be used.

25.5.3 Control panel wiring to be in LS0H insulated stranded conductors, as detailed in the 'Control and Instrumentation' section of this standard.

25.6 Controls

25.6.1 With small and medium sized alternator sets mount the instrument control panel on the main frame of the AC alternator. With large sets, a free standing control cubicle is to be agreed with City University Operations Department.

25.6.2 Where control panels are fixed to the alternator frame or bedplate, resilient mountings shall be used at the bolted fixing points to reduce vibration fatigue in the instrumentation.

25.6.3 Side and/or rear access panels to be provided as necessary to control cubicles.



- 25.6.4 All removable panels shall be secured to the cubicle frame by set screws and be removable only with maintenance tools.
- 25.6.5 All panels, both internal and external, that can be removed for access to live components that operate at potentials of 50V or greater shall be marked "DANGER VOLTS". Danger notices should comply with the relevant Standards.
- 25.6.6 Allow top and/or bottom cable entry to the cubicle as required and due allowance made for cable minimum radius of bending. Suitable provision to be made for tool access above and below the cable glands. The cubicle, trunking or conduit enclosing the wiring to be adequately protected to prevent entry by vermin.

25.7 Control Panel Equipment/Facilities

- 25.7.1 Provide dust proofed, rust proofed mild steel with two primary coats and two finishing coats of oil proof enamel BS4800 00 E 55 full gloss white; to IP44 minimum.
- 25.7.2 Full width access panels/hinged doors secured by lockable handles. Provide two keys.
- 25.7.3 Provide all equipment and facilities required to terminate all incoming and outgoing cables.
- 25.7.4 Incorporate, as a minimum, the following instruments with appropriate labelling to the generating control panel.
 - 25.7.4.1 One 0-500 volt flush mounted 96mm voltmeter and potential fuses.
 - 25.7.4.2 Three 96mm linear scaled, rectified coil fully rated, ammeters and appropriate C/T's.
 - 25.7.4.3 One seven position voltmeter selector switch covering all phase/phase and Phase/neutral readings of alternator output with 'off' position.
 - 25.7.4.4 One 96mm continued frequency dial and pointer meter.
 - 25.7.4.5 One "hours run" meter.
 - 25.7.4.6 Battery voltmeter and ammeter.
 - 25.7.4.7 Frequency indicator.
- 25.7.5 Incorporate, as a minimum, the following controls with appropriate labelling.
- 25.7.6 One rotary duty selection switch labelled "stop" (alternator to shut down if running).
 - 25.7.6.1 "Test (off load)" (alternator to take load in event of mains failure).
 - 25.7.6.2
 - 25.7.6.3 "Off" (completely off even under mains failure).
 - 25.7.6.4
 - 25.7.6.5 "Auto" (set to automatically start and take load in event of mains failure).



25.7.7 NOTE: In "test" position alternator output circuit breaker to remain open (unless mains failure occurs during test).

25.7.7.1 Battery charger Boost/Float/Off switch.

25.7.7.2 Sufficient Emergency lock off stop button located around the installation.

25.7.7.3 Alarm re-set and lamp test push buttons.

25.7.8 Incorporate as a minimum, the following multiple LED indicators with appropriate labelling:

25.7.8.1 Load connected to normal main supply i.e.. ('Transformer' ACB closed).

25.7.8.2 Normal mains supply available.

25.7.8.3 Generator on load. (Generator ACB closed).

25.7.8.4 Overload protection operated.

25.7.8.5 Earth fault protection operated.

25.7.8.6 High coolant temperature.

25.7.8.7 Low oil pressure.

25.7.8.8 Overspeed / Underspeed.

25.7.8.9 High / Low alternator volts.

25.7.8.10 Boost charge in progress.

25.7.8.11 Battery charger fail.

25.7.8.12 Winding temperature.

25.7.8.13 Heater (coolant system) temperature alarm connected to SCADA.

25.7.8.14 Off Normal.

25.7.8.15 Failed to start.

25.7.8.16 Fire valve operated.

25.7.8.17 Low Fuel.

25.7.8.18 Emergency Stop.

25.7.9 Incorporate the following additional equipment with appropriate labelling:



- 25.7.10 Suitably rated four pole MCCB or ACB with necessary auxiliary contacts, shunt trip release, etc. as alternator isolator.
- 25.7.11 Output terminals to duplicate LED indication of conditions listed above for LED indicators on main panel.
- 25.7.12 All other necessary relays, controls and devices to achieve full operation of set as detailed in this Specification. Mount all equipment on back plate within control panel.
- 25.7.13 Instruction label.
- 25.7.14 Restricted earth fault protection relay.

25.8 Engines and Alternators

- 25.8.1 Ensure alternator is designed and manufactured to comply with relevant standards and in general the following requirements:-
- 25.8.2 Continuously rated 3 phase 4 wire star connected machine of screen protected, rotating field, self excited brushless type.
- 25.8.3 Class H stator and rotor winding insulation, with temperature rise in accordance with Class B. An alternative design using Class F insulation is acceptable if economically advantageous, where agreed with City University Operations Department.
- 25.8.4 Anti-condensation heaters to be fitted, to operate when the set is at rest.

25.9 Automatic Voltage Regulators

- 25.9.1 Provide automatic voltage regulator (AVR) as the central feature of the alternator output control and stabilising reference for the electrical protection relays and metering.

25.10 Parallel Running

- 25.10.1 Agree any parallel running requirements with City University Operations Department.
- 25.10.2 Provide electronic (separate or combined) governors with isochronous and/or a maximum 5% variable droop control to ensure balanced load starting and stability between alternators, according to output rating under changing frequency conditions.

25.11 Diesel Engines

- 25.11.1 Ensure the engine is to be of the industrial type to drive an AC alternator. The engine is to have proven long term life and reliability and to be as specified / approved by City University Operations Department.
- 25.11.2 Ensure diesel engine of adequate capacity, rated for unlimited "Prime Power" to drive specified alternator and associated loads, and complying fully with the relevant Standards.



- 25.11.3 Total shielding of rotating and moving parts (pulleys, flywheels, couplings and any other exposed moving parts, etc.) within reach in accordance with the relevant Standards, also exhaust manifold turbos and other exposed-to-touch hot surfaces.
- 25.11.4 Mount set on a common baseplate, complete with fully welded drip tray and suitable anti-vibration mounts. Drain pipe from sump extending through bedframe side member and terminating in gate valve.
- 25.11.5 Fuel system to be fitted with a 24V DC control solenoid. Overspeed protection operating through 24 volt stop solenoid.
- 25.11.6 Engine mounted oil pressure/temperature gauge and water temperature gauge.
- 25.11.7 Filters to be provided for fuel oil, lubricating oil and air intake. Consideration may be given to duplex type oil filters for sets intended to run continuously for lengthy periods.

25.12 Engine Categories

- 25.12.1 The engine categories is to be specified by City University Operations Department and determined for each particular project. Four categories of load acceptance are available for various types of engine operation on the basis of percentage load acceptance for the Class A rating:
 - 25.12.2 Category 1 - 100% load acceptance
 - 25.12.3 Category 2 - 80% load acceptance
 - 25.12.4 Category 3 - 60% load acceptance
 - 25.12.5 Category 4 - 25% load acceptance
- 25.12.6 Naturally aspirated engines have a Category 1 load acceptance, and are more suited for emergency generation, where the cold start initial step loads required are large in proportion to the engine rating. (The frame size of a naturally aspirated engine will be larger than a turbo-charged engine of equal rating).

25.13 Water Cooled Diesel

- 25.13.1 An integral baseplate mounted air water cooling radiator, engine driven fan assisted, is to be provided as standard by manufacturer.
- 25.13.2 The engine jacket and secondary cooling water is to be distilled, ion exchange demineralised water or a potable water with minimal chalk or lime solids in solution and be non-acidic, pH 8 to 10.5. The cooling water is to be treated with an anti-freeze solution containing a corrosion inhibitor, being either a "universal" type with an ethylene glycol base or one conforming to B.S. 4959. The antifreeze to water mixture proportions needed will depend on the minimum freezing temperature against which protection is required and on sufficient corrosion inhibitor being present to protect all metal surfaces in contact with the coolant.
- 25.13.3 To assist in starting in locations where the engine room temperature is liable to fall below 10°C, thermostatically controlled immersion heaters are to be fitted in the engine block at a low level. This is to maintain the jacket water temperature at 42°C, in a minimum ambient of -10°C.

25.14 Engine Starting

25.14.1 Engine to be arranged for 24V starting by means of an axial type starter motor, engaging on toothed ring on fly wheel. Electric starting with a means of disconnecting the starter motor automatically after a predetermined interval shall be used, to prevent heavy discharge of the battery the starter shall disengage and lock out if the engine has not started after 15secs. The starting battery shall be sized for 3 consecutive starts of 15secs with a 20sec rest period between starts. The battery charger shall have sufficient capacity to fully recharge the battery after 2hrs.

25.14.2 The following features are to be provided :-

25.14.2.1 Install high performance nickel cadmium starter batteries of adequate rating for duty cycle of set. Batteries sized to permit minimum three starting sequences at ambient of -10°C. (Minimum life expectancy within proposed operational environment to be greater than 8 years).

25.14.2.2 Install batteries, on heavy duty mild steel painted rack mounted on set. Provide a battery isolator. Provide adequate clearance above battery cells for easy maintenance. Provide heavy duty timber cover over batteries to shield terminals. Ensure batteries are placed in a position where they can be easily replaced.

25.14.2.3 Arrange for set mounted charger alternator to operate when set is running and static charger when at rest.

25.14.2.4 Equip booster charge switch, if provided, with adjustable electronic timer to automatically revert boost to normal charge after period not exceeding eight hours.

25.15 Engine Governors

25.15.1 Ensure the engine is fitted with an electronic speed governor capable of maintaining the rotation speed of the alternator within Class A1 governing requirements of the relevant Standards.

25.16 Fuel System

25.16.1 Provide set base-fixed fuel tank complying with the relevant Standards of mild steel having a capacity sufficient for eight hours continuous running at full load.

25.16.2 Design/manufacture fuel system in compliance with relevant fire and safety regulations and relevant Standards and incorporate automatic shut-off/shut down valves/devices for daily service and bulk fuel supplies and engine in event of fire in enclosure.

25.16.3 Incorporate, in final fuel line connections to engine, appropriate length flexible connections of reinforced metal hose, or equivalent non-combustible material.

25.17 Bulk Storage

- 25.17.1 A service tank is to be located close to the generating set and preferably installed for gravity feed. Arrangements shall be made to ensure oil spillage is not drawn into the alternator winding. Tanks are to be constructed in accordance to the relevant Standards and equipped with the following:-
- 25.17.1.1 filter cap and connection for filling, with oil strainer;
 - 25.17.1.2 vent to atmosphere by pipe to outside of building;
 - 25.17.1.3 dial type oil level indicator, clearly marked to show empty, quarter, half, three-quarter and full. Gauge glasses are not recommended unless fitted with a bottom isolating valve and automatic ball sealing valve;
 - 25.17.1.4 low oil level float, overfill and transfer pump running alarms;
 - 25.17.1.5 connection for the engine fuel oil injector leak-off return pipe (where necessary);
 - 25.17.1.6 drain valves and drain hose connection;
 - 25.17.1.7 electrical bond to the alternator earth connection.
- 25.17.2 Where an emergency generating set requires bulk storage, provide suitably heated and lagged bulk storage facilities with an electrically operated fuel oil transfer pump located close to the bulk storage tank. Where oil is transferred from outside the normal confines of the engine room, provide lagged trace heating around the oil pipework to maintain the oil fluidity during very cold weather.
- 25.17.3 Tanks located inside a building in a minimum 5°C ambient environment shall be housed in an enclosure of two-hour fire resisting construction. All fuel oil tanks to have a catch pit in accordance with the recommendations of the relevant Standards. External oil tanks shall be located also in accordance with the recommendations of the relevant Standards.
- 25.17.4 A hand operated semi-rotary oil pump shall be provided for transferring fuel oil from 50 gallon (227 litre) oil drums or other vessels. The hand pump is to have a filter fitted with screw caps to prevent ingress of dirt when in storage.
- 25.17.5 Ensure tanks incorporate the following facilities:-

25.18 Overfill Alarm

- 25.18.1 Provide Landon 'Kingsway' overfill alarm complete with bulk tank float unit, sounder and control unit.
- 25.18.2 Mount sounder and control unit with contents gauge in lockable box adjacent to the fill valve. Arrange box to ensure sounder not impaired.
- 25.18.3 Provide all necessary wiring and 240V/6V transformer to operate overfill alarm.
- 25.18.4 Use cu/MICS/LSF or cu/LS0H/SWA/LSF cable for wiring. Install transformer in alternator enclosure.
- 25.18.5 Extend 240V supply from MCB distribution board in enclosure.

25.19 Contents Gauge

25.19.1 Provide 'Normond' 150 mm hydrostatic contents gauge at fill point in same box as overfill control panel.

25.20 Exhaust Systems and Terminations

25.20.1 Ensure the exhaust system is kept as short as possible and incorporate a flexible section near the engine outlet manifold to reduce transmission of engine vibration to the remainder of the exhaust system. Bends to have a minimum radius of curvature three times the exhaust pipe diameter.

25.20.2 The exhaust pipework within the building must be provided with heat insulation and clearance from combustible material to reduce fire risk and protect personnel. Care must be taken when exhaust pipework passes through building fabric to ensure adequate fire safe clearance.

25.20.3 Ensure drain valves are fitted in the lower section of exhaust systems to release any accumulation of water condensed from the exhaust gas.

25.20.4 The position and direction of the exhaust outlets are to be selected to reduce noise levels to personnel and the possibility of recirculating exhaust gases entering buildings through doors, windows or ventilation systems.

25.20.5 Incorporate following equipment/facilities/work:-

25.20.5.1 Suitable high attenuation silencers of Residential type to achieve specified noise reduction - 65dBa at 1m from the discharge point.

25.20.5.2 Flexible bellows in first sections of pipes from engine.

25.20.5.3 All piping, fittings and fixings to support complete system.

25.20.5.4 High temperature grade fibre glass thermal insulation with aluminium cladding to insulate all parts of system mounted in acoustic enclosure, and with 2.5 m of ground clearance externally.

25.20.5.5 Termination of pipe in suitable cowl to prevent ingress of rain, projecting sufficiently from building to prevent staining.

25.20.5.6 Thorough cleaning of whole exhaust system, priming and application of two coats of heat resisting, rust inhibiting paint, before erection.

25.21 Exhaust Pollution

25.21.1 Ensure necessary care is taken to safely discharge gaseous pollutants into the atmosphere.

25.21.2 Ensure all the above pollutants are to be limited and controlled in accordance with the current EEC directives for pollution.

25.22 Erection / Installation / Equipment Enclosures.

25.22.1 Include the following work/installation:

25.22.1.1 Anti-vibration mountings.

25.22.1.2 Final positioning of set.

25.22.1.3 Silencers, exhaust pipes and thermal insulation, including provision of all fixings, wall plates, etc.

25.22.1.4 Flexible canvas ductwork between radiator and discharge attenuator. Motorised air inlet louvre and gravity discharge louvre (fixed weather louvres by others).

25.22.1.5 All necessary interconnecting cables between control panel and alternator/engine, louvres etc.

25.22.1.6 Earth bonding of all components, and control panel, including neutral earth connection of the alternator.

25.22.1.7 Provision of first fill of lubricating oil, coolant system with antifreeze solution, daily service fuel tank.

25.22.1.8 Provision of first fill to daily service tank and bulk fuel tank.

25.22.1.9 Fuel for testing purposes.

25.22.1.10 Electrolyte filling of starter battery cells and battery charging.

25.22.1.11 - Acoustic enclosure and attenuators to achieve specified noise reduction.

25.22.1.12 Supply, delivery, off-loading, including craneage, placing in position, complete erection of alternator, acoustic 'container', daily and bulk fuel storage and all associated ancillary systems. (Special attention required to head height and access restrictions).

25.22.1.13 On site commissioning and testing of whole plant.

25.22.1.14 Instruction to the City University Operations Department in operation of plant and standby system including test procedures in conjunction with all other relevant sections of this Specification, and details indicated on the drawings.



25.23 Finishes

- 25.23.1 Apply at works, to equipment of whole plant two priming coats and two finishing coats of oil-proof enamel (gloss) to BS4800 00 E 55 full gloss white.
- 25.23.2 Make good any damage to paint work, caused by any reason, prior to handover of plant.

25.24 Layout

- 25.24.1 The layout is to allow adequate space for maintenance.

25.25 Construction

- 25.25.1 Ensure the engine room and any associated room used for oil storage is of fire resisting construction; in accordance with the relevant Standards.
- 25.25.2 Ensure the main access allows sufficient clearance for the passage of both engine and alternator. Anchor rings shall be provided inside and outside the engine room for drawing in and out the emergency alternator set where access overhead is not provided to off-load with an overhead crane.
- 25.25.3 Doorway openings to other parts of the premises shall be fitted with fire resisting self closing doors (minimum one hour fire resistance). Doors should always open in the direction of the means of escape.
- 25.25.4 Floors shall have a suitable non-slip and oil resisting finish.
- 25.25.5 Internal walls shall have a finish which, as far as possible, resists build up of dirt and can be easily and effectively cleaned.
- 25.25.6 Ensure that the room construction and doors prevent the transmission of airborne noise to adjacent rooms or spaces. When the generating set or sets are running at full load the noise level in adjacent rooms or spaces must not exceed 65dB.

25.26 Ventilation

- 25.26.1 Provide adequate ventilation to ensure satisfactory air supply to the engine and to prevent undue temperature rise in the engine room.
- 25.26.2 An air inlet, which draws directly from the outer air, shall have an effective free area twice that of the engine radiator cooling system and turbo-charger, if provided, and be positioned in the wall so that the cool air is drawn by the engine radiator cooling fan along the line of the emergency alternator set. Where the engine cooling radiator is mounted on the bed plate, air trunking should be used to direct the cooling air through the engine radiator to the outside. This will improve engine cooling and reduce recirculation of radiator hot air around the engine.
- 25.26.3 With air cooled engines the building outlet ventilation shall have an area at least twice that of the water cooled engine hot air outlet.
- 25.26.4 Where natural ventilation is used, outlet vents are to be located at high level and above the engine radiator fan hot air exhaust flow. Inlet ventilation openings shall be provided at a low level in the engine



room where forced ventilation is not used. These areas shall be at least 100% greater than those of the outlet vents to allow entry for combustion air.

25.26.5 Ensure ventilation openings are fitted with louvres or other suitable weather protection and be adjustable to enable them to be closed when the engine is not in use, and so reduce heat losses. With larger sets it may be necessary to have thermostatically controlled inlet and outlet vents, for example motorised louvers controlled by room thermostats with limit switches at the end of each travel direction. With automatic start emergency alternator sets all ventilation louvers shall be either permanently open or be motorised to move automatically to the open position on engine start up.

25.26.6 All ventilation ducts shall be netted over to prevent entry of birds, vermin or large insects.

25.27 Heating

25.27.1 Provide thermostatically controlled heating capable of preventing the temperature in the engine room falling below 10°C. Where electrical heating is used, the heater shall be permanently installed and be of a totally enclosed low temperature type.

25.27.2 Where fuel routes extend to the outside of the building. Ensure pipes are bound with electric trace heating and lagged.

25.28 Lighting

25.28.1 Ensure adequate level of illumination is provided (minimum of 350 lux) in the working area, with good illumination to the front and in the rear of control panels. LED lighting shall ideally be used where the luminaires are connected to different phases. Lighting shall avoid stroboscopic effects involved with rotating machines. Regard must be made for the presence of three hour emergency lighting in the engine and control rooms to ensure illumination is present during blackout conditions.

25.29 Socket Outlets

25.29.1 Provide duplicate 240V 13A radial circuit socket outlets or equivalent with RCD protection at convenient points around the engine room walls and adjacent to control and electrical relay panels. (Refer to LV Power Section).

25.30 Fire Protection

25.30.1 Where oil or gas engines are used, fire extinguishing protection must be provided over all fuel storage tanks and engines. For diesel engines in case of a fuel oil fire, a dead weight isolating valve, closed by a heat fusible linkage, shall be provided.

25.30.2 Refer to City University Operations Department on the fire extinguishing equipment requirements.

25.31 Warning Notices



25.31.1 Provide permanent warning notices of approved type and size, having durable, transparent finish to surfaces. Notices to bear following wording in letters not less than 13mm high for heading, and 6mm for remainder, with white letters on red background:

"DANGER - KEEP CLEAR - THIS SET IS AUTOMATICALLY CONTROLLED AND MAY START AT ANY TIME. WRITTEN AUTHORITY MUST BE OBTAINED AND APPROPRIATE SAFETY PRECAUTIONS TAKEN BEFORE ANY WORK IS UNDERTAKEN IN THIS GENERATOR ENCLOSURE"

25.31.2 Fix a label centrally on external side of each entrance door to alternator enclosure at height of 1525 mm from door base, and also in a prominent position inside alternator acoustic enclosure.

25.32 Accessories

25.32.1 Provide set with:-

25.32.1.1 One kit of tools adequate for all normal maintenance operations, packed in box of adequate strength.

25.32.1.2 Two sets of instructions for starting/stopping, correct operation and routine testing. Instructions to give detailed resume of circuitry events.

25.32.1.3 Two foundation drawings.

25.32.1.4 Two sets of outline drawings of all equipment.

25.32.1.5 Two wiring diagrams.

25.32.1.6 Two electrical circuit diagrams.

25.32.1.7 Two electrical instruction books.

25.32.1.8 Two spares lists.

25.32.2 Provide drawings, wiring and schematic diagrams, instruction books and spare lists, made up in book form with substantial outer covers (or enclosed in heavy polythene envelopes) marked clearly with scheme title and site identification.

25.32.3 Provide books, diagrams, drawings and lists etc., not later than commissioning date.

25.33 On Site

25.33.1 Arrange for generator Specialist to provide all equipment, apparatus and accessories required to carry out on site full load and 110% full load tests using load banks provided by specialist.

25.33.2 Demonstrate to City University Operations Department satisfactory operation of all alternator functions and controls, including voltage level setting and safety devices.

25.33.3 Carry out these tests prior to connection of standby supply to Main LV System.

25.33.4 Demonstrate all sections of Generator installation and controls/operation in conjunction with main L.V. switchpanel to City University Operations Department.



25.33.5 Carry out acoustic site test measurements to the requirements of City.

25.34 Acoustic Generator Enclosure

25.34.1 When specified provide "walk-in" acoustic weatherproof enclosure incorporating the following facilities/equipment/ features:-

25.34.2 Two, minimum, acoustically lined, airtight, personnel access doors, located on opposite sides of engine with one opposite control panel, fitted with heavy duty, rust proofed ironmongery and locks. Locks to match City University Operations Department suite locks. All access doors with antirattle pads.

25.34.2.1 Having internal dimensions to ensure all necessary maintenance can be carried out easily.

25.34.2.2 Width - 600mm each side.

25.34.2.3 Length - 1000mm from control panel to inlet end.

25.34.2.4 Framework of fabricated steel having adequate strength to support panels, fitted with permanent lifting facilities to permit lowering on to prepared base.

25.34.2.5 Inlet and outlet attenuators of bolt-on type.

25.34.2.6 The enclosure shall when the generator is running at full load have a maximum noise level of 65dBa at 1m from any point outside the enclosure.

25.34.2.7 Whole enclosure is to satisfy Class 1 Spread of Flame.

25.34.2.8 Enclosure to be sealed to prevent leakage of water and oil.

25.34.2.9 Provision of Bird and insect mesh to louvres.

25.35 Container Housed Units

25.35.1 Standard ISO type freight containers may be used to house engine driven alternators ensure:-

25.35.1.1 the complete unit can easily be lifted, transported and placed in locations that need not be purpose built;

25.35.1.2 the robust construction allows for a minimum of site foundation preparations;

25.35.1.3 the whole generating set is enclosed in its own packing case. The container gives good protection mechanically and against the weather;

25.35.1.4 the structure can be easily insulated acoustically or thermally. On site commissioning can be reduced to a minimum;

25.35.1.5 The enclosure shall when the generator is running at full load have a maximum noise level of 65dBa at 1m from any point outside the enclosure.



25.35.1.6 for small generating sets the container may incorporate removable covers for plant access, while for sets of 200 kVA or more, there is a requirement for "walk-in" access.

25.36 Generator Self Contained Enclosure Auxiliaries

25.36.1 Include provision by alternator specialist of following auxiliary equipment within enclosure:

25.36.2

25.36.2.1 LED luminaires with housed in plastic housing with clip on covers, located to illuminate control panel front and all service/control points of plant.

25.36.2.2 Self-contained, non-maintained, 3 hour duration, LED emergency lighting bulkhead located to illuminate front and interior of control panel.

25.36.2.3 Industrial type lighting switches, controlling luminaires (one per door) incorporating emergency lighting test switch.

25.36.2.4 Two industrial type twin 13 Amp switched socket outlets one each side at opposite ends of plant, RCD protected, each on a dedicated radial circuit.

25.36.2.5 Volt free circuit to Fire Alarm/Detection equipment.

25.36.2.6 Distribution Board fitted with type 2 M16 MCB's of appropriate rating and 100A TPN 'on-load' isolator to feed auxiliaries detailed in this Clause.

25.36.2.7 Circuit to coolant system heater with isolating switch.

25.36.2.8 Circuit plant starter battery charger.

25.36.2.9 All necessary wiring (High temperature Cu LS0H in conduit or MICS/LSF copper conductor) from Distribution Board to lighting points, switches, socket outlets and other equipment described in the specification.

25.36.2.10 Provide facilities for installation of 2 No. fire alarm xenon beacons.

26 UPS SYSTEMS

- 26.1.1 To permit maintenance, or in the event of a complete UPS failure, the whole UPS shall be complete with an external wrap round bypass complimented by an isolating transformer in series with a solid-state bypass switch or a mechanically operated overall bypass switch fed from another point of essential services supply. That by-pass system must comply with the relevant sections of the G59 regulations.
- 26.1.2 A UPS shall recognise mains failure as an undervoltage in excess of 5% of the nominal supply voltage and a frequency deviation in excess of 5% of the nominal supply frequency.
- 26.1.3 Three phase UPSs shall not rely on the integrity of the supply neutral for the reference point of the system, the reference point for the system shall be the output neutral which shall be isolated from the supply system neutral and separately earthed. Where due to the UPS design this is not possible then the contractor shall supply a Dzn 400/400V transformer to feed the UPS.

26.2 Rotary Systems

- 26.2.1 Critical loads may justify the specification of a rotary UPS system or combined rotary and diesel generator system. The requirements will be identified on individual projects.

26.3 Static Inverter Systems

- 26.3.1 To reduce load generated voltage distortion, provide low pass filter traps at the inverter output terminals. (These filter harmonics from the voltage output waveform and helps to reduce any over-rating of the UPS required to match the load).
- 26.3.2 Ensure the UPS manufacturer analyses the equipment load waveform crest factor and harmonic distortion to determine the correct UPS rating. Generally allowance shall be made for a 3:1 crest factor and 20% spare capacity when sizing UPS load, the duration of time and the kVA rating can be supplied is to be 30 minutes. (The load characteristics of electronic equipment such as computers are normally non-linear and, as a result the UPS required will be twice the kVA rating that would be expected from a linear load).
- 26.3.3 Provide earthing systems to ensure that no mains-borne interference and transients occur. Methods of earth connection at the UPS output side may differ to suit the load.

26.4 Harmonic Distortion in Uninterrupted Power Supplies

- 26.4.1 Ensure the level of harmonic injection at the normal supply point of common coupling is not exceeded, in accordance with the Electricity Association Engineering Recommendation G5/3 (1976) - "Limits of Harmonics in the UK Electricity Supply System", and relevant Standards.

26.5 Protection of Uninterrupted Power Supplies

- 26.5.1 A three-phase output UPS is to be able to cope with 100% unbalanced loads on each phase, while still providing a closely regulated output voltage and phase control.



- 26.5.2 Ensure that in high impedance UPS outputs, voltage or current sensitive inverter protection is provided. Fault clearance must be achieved without the assistance of the normal power supply. The low impedance normal power supply will assist the load circuit protective devices. It is essential that suitable primary protection is installed on the supply side and graded to the load circuit.

26.6 Installation

- 26.6.1 Where large installations are required, the location shall be separate from, but near to, the data equipment and in the central area of a building. Due consideration must be given to the concentration of equipment such as batteries and transformers, structural design must consider the extra floor loading, space for extra air conditioning cooling and cableworks, and the lifting, access and possible removal of large equipment cubicles during and after construction.
- 26.6.2 For applications where UPS loads (including during witness tests) are likely to be resistive, or any load between 0.8 lagging to unity (1) power factor, then the rated battery capacity should be increased to ensure full rated UPS output is available.
- 26.6.3 The unit is to be connected to the mains supply via mains 1 and mains 2 essential LV power supplies. Mains 2 will be connected via an isolating transformer in a matching cubicle, and incorporate maintenance bypass facilities.
- 26.6.4 Mains 2 transformer isolation is to reduce requirements for neutral bonding criteria. For 3 phase UPS systems, the star point must be earthed by ensuring neutral is bonded to electrical system earth. No separate star point secondary earth bond should be allowed.

26.7 Voltage free contacts may be used for other monitors/systems.

- 26.7.1 The UPS panel is to incorporate connection ports as agreed with City University Operations Department to signal the need for automatic computer system shutdown in the advent of generator and mains failure. Connection to the UPS ports will be the responsibility of others.
- 26.7.2 A telephone point is to be provided adjacent to the UPS panel.
- 26.7.3 Where 3 phase UPS systems are specified and feeding unbalanced (SPN) loads, then care in circuit design due to high neutral currents needs to be considered. Neutral/conductor cables are to be sized at 1.5 times the design/calculated size for the phase conductors.
- 26.7.4 Do not deliver the batteries until the complete system is ready for test. Ensure that batteries do not degrade during the construction stage of the works.

26.8 System Overview

- 26.8.1 Provide the UPS installation to comprise the following:-
- 26.8.2 To ensure a steady energy flow regardless of any break-down in the site energy supply. Design the installation to achieve the load requirements at the installation stage of the particular project. Provide a system capacity for 20% future expansion of the UPS load.

26.9 Single phase UPS may use neutral as a reference point.

- 26.9.1 Ensure on SPN UPS systems, incoming MCB is only SPN type (unswitched neutral).

26.10 System Operation and Performance

26.10.1 Provide UPS system to operate as follows:-

26.11 Normal Operation (Input Power Present)

26.11.1 The rectifier/charger derives AC power from the input source and supplies DC power to its inverter while simultaneously float charging the battery.

26.12 Operation on Battery Power (Input Power Outage)

26.12.1 On loss of mains or excessive deterioration of the input AC source, the inverter must continue to supply the load from battery power without interruption or disturbance.

26.13 Battery Recharge (Input Power Restored)

26.13.1 When the input source is restored, the rectifier/charger must power the inverter, without interruption or disturbance to the load, whilst at the same time automatically recharging the battery. The charging rate to be client adjustable.

26.14 Automatic Bypass (Static Switch)

26.14.1 In the event of overload exceeding system capabilities (short-circuits, heavy inrush currents, etc.) or inverter shutdown (manual for maintenance or automatic for internal faults), the static bypass transfer switch instantaneously transfers the critical load to the bypass AC input source without interruption. Ensure the load shall be gradually transferred back to the inverter output, either manually or automatically, without interruption, once the inverters have been synchronised to the bypass source.

26.15 Manual Bypass (Maintenance)

26.15.1 Include on the UPS a manually operated mechanical bypass system for maintenance purposes.

26.15.2 Ensure, for personnel safety during servicing or testing, the system isolates the rectifier/charger, inverter and static system while continuing to supply power to the load via the bypass AC input source.

26.15.3 Ensure transfer to the maintenance bypass, is possible without interruption to the load.

26.15.4 Provide a further isolating device to isolate the rectifier/charger from its input source.

26.15.5 Ensure the inverter, in such a case, remains connected to the parallel bus and continues to supply the load without interruption or disturbance, provided the mains supply remains within operating tolerances.

26.15.6 Provide for the UPS to continue to function as specified, except for input outage protection.

26.15.7 Provide the UPS System rating as follows:-

26.15.8 Sized to supply load at 0.8 PF.



26.15.9 Battery protection time, in the event of an input power outage, to be 30 minutes (to be confirmed by City University Operations Department).

26.16 Inrush Currents

26.16.1 Provide UPS design to eliminate overcurrents during start up by imposing a gradual increase of the rectifier/charger DC output voltage over a period of approximately 10-15 seconds.

26.17 Input Power Factor

26.17.1 Ensure the rectifier/charger presents an input power factor greater than 0.80 for the normal AC input source rated voltage and frequency and its inverter operating at rated full load.

26.18 Battery Unit

26.18.1 Size the batteries to ensure power supply continuity to the inverter for at least 30 minutes in the event of an outage on the normal input supply, with the UPS operating at rated load. Minimum design life at 20-25 deg C must be 10 years.

26.18.2 Base battery ratings on an operating temperature of 20°C.

26.18.3 Ensure the UPS manufacturer offers the battery type best suited to operating constraints (environmental conditions, installation location, etc.).

26.18.4 Ensure that low ambient temperature is controlled to minimise effects on:-

26.18.4.1 Rated capacity of batteries, in UPS.

26.18.4.2 Life of batteries (above 20°C).

26.19 Battery Rooms

26.19.1 Always install batteries on purpose designed racks in a dedicated room with stand alone N+1 environmental temperature control equipment. Battery chargers and other UPS equipment should be installed in separate dedicated rooms.

26.19.2 Ensure batteries or chargers are not located in areas of vibration or with free access by unauthorised personnel.

26.19.3 Ensure all battery rooms display a clear and legible notice advising staff of the type of electrolyte in the batteries and the dangers of gas explosion. Mixed storage of acid and alkaline battery electrolytes is forbidden.

26.20 Inverter

26.20.1 Ensure the inverter is sized to supply a rated load at 0.8 PF and satisfy the following specification. Output voltage rating: 400 volts. Wiring: 3 phase, 4 wire and ground Steady state voltage regulation: +/- 1% for a balanced load between 0 and 100% of rated full load irrespective of normal input source and DC



Voltage levels within the limits specified in the "Normal Input Source" and "DC Source" sections of the Specification.

26.20.2 Transient voltage regulation: Output voltage transients not to exceed +5% or - 5% of rated voltage for a 100% load change.

26.20.3 Ensure in all cases, the voltage returns to within steady state tolerances, in less than 20 milliseconds.

26.21 Harmonic distortion

26.21.1 Provide the inverter with an output filter limiting total harmonic distortion of the phase-to-phase output voltage to 5% and individual harmonic distortion to 3% for a balanced linear load.

26.22 Overload Capabilities

26.22.1 The UPS shall be able to supply 125% rated full load for 10 minutes and 150% rated full load for one minute.

26.23 Static Switch

26.23.1 Provide the UPS system with a static switch enabling instantaneous load transfer from the inverter to the bypass AC input source and vice versa without interruption or disturbance, provided that the bypass source voltage and frequency are within the limits specified in the "Bypass input Source" (inverter synchronised to bypass source).

26.23.2 Ensure transfer takes place automatically upon overloads exceeding rated capabilities or internal inverter faults. Ensure manually initiated transfer is also possible.

26.23.3 Ensure, if the bypass source is outside the specified limits when the overload occurs, the load automatically transfers to the bypass source only after an interruption of approximately 200 milliseconds. Ensure manual initiation of transfer as well automatic transfer back to the UPS is possible.

26.24 Enclosures

26.24.1 Ensure UPS enclosure is designed with a strong and rigid framework capable of withstanding handling and installation operations. Configure UPS to suit the area/room as shown on the particular project drawings.

26.24.2 Provide access to UPS subassemblies via front doors equipped with locking facilities. Ensure rear panels are removable.

26.24.3 Protect sheet metal against corrosion by a suitable treatment such as zinc electroplating, bichromating, epoxy paint or equivalent. Mount enclosure on purpose made plinths supporting the UPS and transformer to the level of the false floor, transferring weight to the structural slab, where applicable.

26.25 Ventilation

26.25.1 The UPS shall be provided with forced-air cooling as necessary.



26.25.2 To avoid UPS shutdown in the vent of a fan failure, redundant fans shall be provided on the UPS.

26.26 Safety

26.26.1 Provide UPS equipment to meet the requirements of protection index IP20.

26.26.2 Provide, for the safety of maintenance personnel, UPS cubicle with a manually operated mechanical bypass designed to isolate the rectifier/charger, inverter and static switch while continuing to supply the load via the bypass AC source.

26.26.3 Ensure control circuits can be completely isolated from power circuits and suitably labelled.

26.26.4 Protect accessible live parts by insulating shields.

26.26.5 Ensure all equipment is designed and built in accordance with accepted engineering practice and, in particular with the relevant Standards.

26.27 Maintainability

26.27.1 Ensure all UPS module subassemblies are accessible from the front.

26.27.2 Provide standard adjustment-free replacement subassemblies, to assist repairs.

26.27.3 Provide the UPS with a start-up and operating assistance system providing in particular:-

26.27.3.1 Display of installation parameters, configuration, operating conditions, alarm status, etc. and step-by-step instructions for switching operations (e.g. bypass).

26.27.3.2 Storage in memory and automatic or manually initiated recall of all important status changes, faults and malfunctions, complete with an analysis and display of troubleshooting procedures.

26.28 Protection Devices

26.28.1 Include UPS protection against overvoltage, load short-circuit, external or internal over temperature, vibrations and impacts during transport, etc.

26.28.2 Ensure each rectifier/charger is equipped to receive an external command for automatic shutdown and the tripping of the associated battery circuit breaker in the event of an emergency.

26.28.3 Provide the rectifier/chargers equipped to receive an external automatic shutdown order in the event of a battery room ventilation fault.

26.29 Controls

26.29.1 Provide a keypad to carry out the following operations:-

26.29.1.1 Rectifier/charger on/off.



- 26.29.1.2 Inverter on/off.
- 26.29.1.3 Forced transfer for forced shutdown of inverter when the bypass AC source is outside specified tolerances.
- 26.29.1.4 UPS self-test.

26.30 Monitors

26.30.1 Monitor the following status information by indicating lights on the UPS front panel, provide remote indication to SCADA system:-

- 26.30.1.1 Rectifier/charger on.
- 26.30.1.2 Load on inverter.
- 26.30.1.3 Load on bypass.
- 26.30.1.4 General alarm.

26.30.2 Provide an audible alarm of faults, malfunctions or operation on battery.

26.30.3 Provide the system with an alarm reset button.

26.31 Metering

26.31.1 Ensure display indicates the following measurements:-

- 26.31.1.1 Inverter output line-to-line voltages.
- 26.31.1.2 Inverter output currents.
- 26.31.1.3 Inverter output frequency.
- 26.31.1.4 Voltage across battery terminals.
- 26.31.1.5 Battery charge or discharge current.
- 26.31.1.6 Normal AC input source line-to-line voltages.
- 26.31.1.7 Rectifier/charger input currents.

26.32 Testing and Commissioning

26.32.1 Provide proof of UPS manufacturers Quality Assurance program and works inspections and testing e.g. components inspection, discrete subassembly testing and complete functional checks on the final



product.

- 26.32.2 Ensure equipment has undergone onload burn-in before leaving the manufacturers works.
- 26.32.3 Ensure final inspection and adjustments are documented.
- 26.32.4 Carry out complete testing, commissioning and demonstration of the UPS system to ensure and prove its full compliance with this specification together with all other relevant standards etc.
- 26.32.5 Prepare a fully detailed, easy-to-follow method statement stating exactly how the test, commissioning and demonstration is to be carried out. Submit two months in advance to City University Operations Department.
- 26.32.6 Carry out test and commissioning of the UPS installation in accordance with the relevant Standards and include:-
- 26.32.7 Witness sites tests to UPS installations, carried out with inductive (0.8p.f.) load bank tests, and/or UPS derating factor taken into account, depending upon connected load bank power factor.
- 26.32.8 Total simulation of mains failure with the UPS systems battery support for the full specified time under the following loads:-
 - 26.32.8.1 No load.
 - 26.32.8.2 Half load.
 - 26.32.8.3 Full load.
 - 26.32.8.4 Fault current limit check for a simulated load fault.
 - 26.32.8.5 Full test of displays and instruments.
- 26.32.9 Measurement of the harmonic distortion at the output and input under the following loads:-
 - 26.32.9.1 No load.
 - 26.32.9.2 Half load.
 - 26.32.9.3 Full load.
 - 26.32.9.4 Full discharge test of the batteries and demonstration of the recovery time over the specified 24 hour period.
 - 26.32.9.5 Issue all recorded factory and on-site test results in the "Operations and Maintenance Manual" at contract completion, with advance copies issued to City University Operations Department, following each group of tests.

26.33 Documentation and Maintenance

- 26.33.1 Provide on contract completion and hand-over, the following documentation in respect to UPS systems.



26.33.2 Manufacturer's installation and wiring diagrams.

26.33.3 Manufacturer's Operating and Maintenance Manuals'.

26.33.4 Testing and commissioning certificates.

26.33.5 Obtain from the manufacturer a schedule of recommended spares to be held at site.



CABLING SYSTEMS

27 CABLE SELECTION / INSTALLATION

27.1 General

- 27.1.1 All cables shall be of BASEC manufacture and of the low smoke, zero halogen type for indoor installation for outdoor installations LZH shall not be used, unless prior written approval is given by City University Operations Department.
- 27.1.2 The method of cable installation will depend on a number of factors, such as type of cables selected, location, environmental factors/conditions, aesthetics etc.
- 27.1.3 Deliver, off load including crange and store cables on site on the manufacturer's drums/reels/coils.
- 27.1.4 Ensure, where applicable, cables on drums are of substantial construction with centre hole reinforced, two non-deteriorating indestructible labels are fixed to each drum, one inside and one outside the drum flange.
- 27.1.5 Ensure all cables are new with each coil, drum or reel having its seal intact and having the following information indicated:-
 - 27.1.5.1 Manufacturer's name.
 - 27.1.5.2 Size, number of conductors, voltage grade, type of cable, classification.
 - 27.1.5.3 Length in metres on drum/reel/coil.
 - 27.1.5.4 Gross weight (where applicable).
 - 27.1.5.5 Order number.
- 27.1.6 Ensure all cables are by the same manufacturer, where possible, for each particular project and installation.
- 27.1.7 Deliver and store cables to manufacturer's recommendations with the ends sealed to prevent ingress of moisture and escape of insulation or impregnation. Cable ends cut on site which are not to be terminated immediately should also be sealed. Ensure all cable ends are sealed upon completion of tests.
- 27.1.8 Do not handle or install cables when the temperature is below 0°C. Allow a minimum period of 24 hours before cables are used if the cables have been exposed to such temperatures.
- 27.1.9 Run cables from the tops of their drums, with supporting ramps if necessary, the drums being braked to avoid over running.
- 27.1.10 Do not impose stress on cables by twisting or stretching forces. Allowance shall be made for expansion joints in large buildings and structures.
- 27.1.11 Lay multiple cable runs so that minimal crossing of cables occurs.
- 27.1.12 Do not exceed minimum bending radii for each cable type, size, installation arrangement and detail.

- 27.1.13 If the cable is damaged in any way during installation, it shall be made good or replaced, free of charge, as dictated by and to the satisfaction of City University Operations Department.
- 27.1.14 Ensure conductor sizes to any cables are designed and installed not less than 1.5mm², except for flexible cords with minimum conductor size of 0.75mm², or where other minimum conductor sizes are indicated on the particular project drawings or in the Specification.
- 27.1.15 Ensure all cable types and specifications are designed and installed to be suitable for the environmental conditions which the cables will encounter in service.
- 27.1.16 Cables and containment installed in or above fire escape routes shall be fixed to the building fabric using non-combustible fixings, cleats or ties.
- 27.1.17 Use overhead lines only where specifically necessary for the particular project requirements, and only following agreement by City University Operations Department.
- 27.1.18 Use cable sheath and core colours where identified in the Specification and also identification as given in the relevant Standards. Use coloured sleeves only if permitted and with agreement of City University Operations Department.
- 27.1.19 Design/install cable routes and locations where possible at high level so as to be beyond the reach of people and moving equipment. Cables, trays, ladders, trunkings, baskets and other containment shall be accessible once installed. They shall not be installed to prevent or limit access to other equipment risers or enclosures.
- 27.1.20 On cable racking, cable ladder and where fixed directly to the building fabric cables shall be secured with correctly sized metallic or plastic cable cleats. Except for cables in tre-foil and control cables only one layer of cables shall be permitted on horizontal racking or ladder.
- 27.1.21 On cable tray cables shall be secured with correctly sized cable ties. Except for cables in tre-foil and control cables only one layer of cables shall be permitted on horizontal cable tray.
- 27.1.22 Cables run horizontally shall be fixed at intervals not exceeding 15x the cable diameter or 450mm whichever is the lesser and for cables run vertically shall be fixed at intervals not exceeding 20x the cable diameter or 600mm whichever is the lesser.
- 27.1.23 Ensure cables designed and installed at low level in accessible or vulnerable positions, particularly where rising from the floor, have additional mechanical protection such as earthed steel pipe or channel up to a height of 3 metres above floor level or as otherwise required by the location. Protect cables passing through walls with tubular sleeves set into the wall. Finish sleeve ends flush with the wall finish, with rounded edges to avoid damage to the cable sheath when drawn through. Ensure the sleeves are of adequate bore to enable easy cable drawing, and packed with approved fire resistant material after cable installation. Ensure for single core cables, sleeves are non-metallic.
- 27.1.24 Protect all fixing cleats, cable tray and associated nuts, screws, bolts and frameworks against corrosion.
- 27.1.25 Agree final selection and routing with City University Operations Department prior to installation.
- 27.1.26 Apply additional derating factors for design and installation of externally exposed cables, where effects of solar heat gain will occur.



- 27.1.27 Provide manufacturers works test certificates as required in the relevant British Standard for all cable types and specifications installed, in addition to installation test certificates and schedules required in the Specification. Submit duplicate copies of all test certificates and schedules In CU format only.
- 27.1.28 Do not use soldered connections or lugs. Terminate all conductors requiring bolted connections with compression lugs using automatic compression crimp tools which will only release after the correct crimp depth has been obtained. Use spring washers on all bolted connections.
- 27.1.29 In the event of any damage occurring to cables while in store, installation or during testing, remove and replace the whole of the cable length.
- 27.1.30 Ensure all conductor terminations are made by compression joints as indicated in the Specification by a competent person.
- 27.1.31 Wrap in the correct colour coded PVC insulation tape bound to the thickness of the original conductor insulation. Heat shrink-on sleeves are acceptable.
- 27.1.32 Ensure correct phasing out of all cores prior to the commencement of connections.
- 27.1.33 Ensure all bolted terminations have suitable bolts, nuts and shakeproof washers, adjusted to the correct torque.
- 27.1.34 Connections of the pinch screw type are not permitted, other than in final small power and lighting circuits.
- 27.1.35 Measure actual cable route lengths to ensure correct and continuous lengths are delivered. No joints will be accepted without prior agreement with City University Operations Department.
- 27.1.36 Where use of joints is agreed and for cable terminations:-
- 27.1.37 Use skilled craftsmen fully experienced in terminating and jointing the types of cable specified. For HV cables specify and/or use an suitably experienced company approved by City University Operations Department.
- 27.1.38 Provide adequate protection from all weather conditions for exterior work.
- 27.1.39 Make all cable joints using a proprietary system supplied by one manufacturer and install strictly in accordance with their instructions for each particular cable type.
- 27.1.40 Carry out each termination or joint to completion without interruption.
- 27.1.41 Ensure terminations, glands, sealing boxes, etc. do not transmit stress onto switchgear from adjacent bends in the cables.
- 27.1.42 Paint exposed armoured with bitumastic paint.
- 27.1.43 Protect metal glands by LS0H shrouds of same colour as the cable sheath.
- 27.1.44 Ensure suitable measures are taken to prevent circulating current in switchgear metalwork caused by individual conductors.



- 27.1.45 Provide for conductor terminations of a suitable type and size for the equipment terminals to which the cables are connected.
- 27.1.46 Include glands and joints having suitable accessories for earthing of armour and sheaths as detailed in the Specification.
- 27.1.47 Provide copper bonds within the joint to maintain full earth continuity. Ensure the resistance is no greater than that of the live conductors and the insulation resistance between cores, and between cores and earth, is no less than that of the original cable.
- 27.1.48 Ensure, where jointing to switchgear, and equipment, that for phases, when viewed from the front of the switchgear, the brown / red phase is on the left, black or yellow phase is in the centre and grey / blue phase is on the right.
- 27.1.49 Carry out tests upon completion of all cable joints and terminations in accordance with the Specification including phase rotation tests where applicable.
- 27.1.50 Ensure all cable joints and terminations are suitable and fully compatible with the switchgear and/or equipment and manufacturers requirements.
- 27.1.51 Provide in design and/or installation for segregation of all cable and wiring types and systems in accordance with all Regulations, Standards and Codes etc.

28 LV CABLES IN CONDUIT AND TRUNKING

28.1 Cables

- 28.1.1 Install single core cables LSZH insulated, as agreed with City University Operations Department, copper conductors 450/750 volt grade complying with the relevant Standards.
- 28.1.2 Install flexible cords in accordance with the relevant Standards with a rating of 300/500 volts.
- 28.1.3 Where heat resistant cables are specified use silicon rubber and comply with the relevant Standards, or other heat resistant cable of similar temperature group conforming to the relevant Standards.

28.2 Installation

- 28.2.1 Carry out all wiring of multi-point circuits in a "loop-in" system, and do not use joints or connections, other than those required for the connection of switches, fuses, socket outlets, motors etc.
- 28.2.2 Ensure cables are not in direct contact with any form of polystyrene used in the building.
- 28.2.3 Identify elastomer insulated cables throughout the length of the cable by the legends:-
 - 28.2.3.1 "Heat Resisting 85" - for EP or butyl rubber insulated cables.
 - 28.2.3.2 "Heat Resisting 150" - for silicone rubber insulated cables.
- 28.2.4 Do not use PVC cables for final connections to any appliances containing a heating element or any appliance emitting heat. Where flexible conduit (maximum length 500mm) is used as a final connection wiring medium, use heat resistant cables and these shall commence at the solid conduit end of the flexible conduit provided it is not in a heated area. If this is not possible, install heat resistant cables back to the first switch or distribution board not in a hot area.
- 28.2.5 Design and install cables in order not to exceed the capacity of the conduit and/or trunking systems.
- 28.2.6 Where cables are concealed in floors, walls, ceilings or similar structural elements they shall be contained in earthed solid metallic conduit.

28.3 Circuit Protective Conductors

- 28.3.1 Ensure that the protective conductor is sized in accordance with the relevant Standards, and in accordance with the Specification requirements for earthing.
- 28.3.2 Do not use conduits and trunking, as circuit protective conductors, except where indicated in the Specification. Install Circuit Protective Conductors and ensure these cables are of the same grade and temperature rating as those of live conductors of that part of the circuit. Circuit Protective Conductors insulation shall be of green and yellow colour.
- 28.3.3 Ensure that each circuit has its own protective conductor emanating from the distribution position and installed in the same trunking/conduit as the live conductors of that circuit.



- 28.3.4 Clearly identify the protective conductor by cable markers at each earthing terminal on all equipment. Fix labels to each equipment box, appliance box etc., adjacent to the earthing terminal stating:-
PROTECTIVE CONDUCTOR – DO NOT DISCONNECT.

28.4 Cable Sizing and Circuiting

- 28.4.1 Design/install socket outlets, connection units, etc., from radial circuits and size in accordance with the relevant Standards.
- 28.4.2 Fit all circuit conductors with appropriate identification sleeves of the type outlined in the relevant Standards.

29 LS0H/LS0H INSULATED AND SHEATHED CABLES

29.1 General

- 29.1.1 Ensure cables are LS0H insulated and sheathed complying with the relevant Standards.
- 29.1.2 Ensure no current carrying conductor less than 1.5 sq. mm is used. Ensure cables have stranded copper conductors, twin core and combined circuit protective conductor (CPC) with overall LS0H sheath; use multi-stranded for cable of 4mm size and above.
- 29.1.3 Fully enter all cable sheaths into the box via a rubber insert bush and web. Ensure the protective conductor has green/yellow sleeving where connecting to the earthing terminal. Install a separate green/yellow sleeved protective conductor from the box earthing terminal to the earthing terminal of the accessory or appliance.
- 29.1.4 Use packed glands with neoprene washers in lieu of the rubber insert bushes, in class 4 areas.

29.2 LS0H Insulated and Sheathed Cable – Surface Installation

- 29.2.1 Install cables as inconspicuously as possible, taking advantage of the features of the building by fixing in corners, behind or along skirting boards, mouldings etc., and behind fitments etc.
- 29.2.2 Protect the cables by solid metal conduit or channel to full height where rising from the floor. Increase the protection height to 2m where there is a possibility of heavy traffic.
- 29.2.3 Sleeve all cores with heat resistant sleeving from the point of entry into the luminaire and up to the terminals, where wiring terminates at a luminaire other than a ceiling rose.

29.3 LS0H Insulated and Sheathed Cable – Concealed Installation

- 29.3.1 Concealed installation is not permitted. This includes “Twin and earth” type cables. All concealed installations must be single core cables in earthed metallic conduit.

30 ARMoured CABLES – LS0H OR XLPE INSULATED - LV/HV

30.1 Cables

- 30.1.1 Include single core or multi-core copper conductors, unless specified otherwise in the Particular Project Specification.
- 30.1.2 Abbreviation L.SZH or LS0H in lieu of PVC sheath indicates low smoke zero halogen. Agree requirements with City University Operations Department in writing for applications not using LSF sheathed cables.
- 30.1.3 Ensure single core cables operating on ac. systems do not have steel wire armouring.

30.2 Cable Terminations

- 30.2.1 Supply cable glands for all terminations.
- 30.2.2 Use brass type E1W compression glands for steel wire armoured cables.
- 30.2.3 Use aluminium alloy glands for aluminium armoured cables suitable for accepting insulated insert when used on single core cables.
- 30.2.4 Terminate cable cores direct to the terminals of the equipment.
- 30.2.5 Use non-ferrous gland plates for single core cables.
- 30.2.6 Install suitable seals to provide a moisture-proof seal between the bush and the outer serving, and the bush and the inner sheath. Ensure glands have core grip armour clamps with suitable provision for cross-joint bonding.
- 30.2.7 Ensure all cable joints and connections are electrically and mechanically sound.

30.3 Installation of Armoured LS0H/XLPE Insulated Cables

- 30.3.1 Install cables as indicated on the drawings and detailed in the following:-
- 30.3.2 Arrange cable routes so that cables, hangers, cleats, etc., do not come into contact with, or in close proximity to, pipe services. Space to the requirements of the relevant Standards. Check all routes on site for correct measurements and practicability. Co-operate with other trades and ensure close liaison to avoid conflict of services.
- 30.3.3 Ensure cable routes, where fixed on walls or installed in accessible ducts, are fixed at intervals to prevent sag, in accordance with the manufacturer's recommendations and the relevant Standards.
- 30.3.4 Fix cable installations in air, including engineering service ducts, with aluminium alloy or approved claw cleats with galvanised back strap using galvanised bolts conforming to current requirements/regulations,

with maximum spacing between supports as detailed in the relevant Standards. Fix cleats for cables up to and including 50mm diameter by a single bolt, and above 50mm diameter by 2 bolts. Avoid excess pressure of cleats on cables to prevent deformation of the plastic sheathing. Provide suitable supporting steelwork and/or galvanised cable tray where cables cross open spaces. Protect such steelwork by a rust inhibiting paint.

- 30.3.5 Fix cable cleats to brickwork using expanding masonry bolts, or approved fixing device agreed by City University Operations Department. Drill all holes necessary and allow for making good around cable fixings.
- 30.3.6 Fix cables laid in racks, hangers or on steelwork at intervals to prevent sag, in accordance with the relevant Standards.
- 30.3.7 Obtain approval from City University Operations Department before installing racks and hangers and for any non-standard equipment.
- 30.3.8 Ensure all joints have the armouring bonded across, and at termination points are bonded to the switchgear. Use copper conductors of the correct size in accordance with the relevant Standards.
- 30.3.9 Ensure cables passing through walls and floors have oversized sleeves permanently fixed, packed with fire resisting infill. Ensure where cables rise or fall on walls they are protected to a height of 2m with an earthed sheet steel guard.
- 30.3.10 Ensure all cables are neatly installed, straightened and dressed to give a neat and workmanlike installation.

30.4 11kV Cabling

- 30.4.1 Use 3 core, 6350/11000 volt, XLPE insulated cable, copper conductor, steel wire armoured, screened, with red LS0H over sheath, to the relevant Standards, for internal use use LSF/LZH.
- 30.4.2 Ensure cable is suitable for continuous operation at its maximum design current in ambient temperatures of 30°C maximum without derating.
- 30.4.3 Utilise Specialist Sub-Contractor or joiner, experienced in 11kV cabling to make all 11kV joints at switchgear, including transformers. Such personnel to be formally approved by cable manufacturer as being competent, and agreed with City University Operations Department.
- 30.4.4 Use heat shrink type seals for terminations to 11kV switchgear and transformer.
- 30.4.5 Test cables and terminations, on completion of all joints, in accordance with test procedures detailed in the Specification before energising any sections of the new works. Tests to include phase rotation and pressure tests etc.
- 30.4.6 Ensure City University Operations Department's 'Authorised Person' is present and has authorised work before inspection, survey, isolation, switching and re-energisation of any section of 11kV works. Ensure all relevant and appropriate site safety rules and regulations are used when working on any section of 11kV works or cable installation.
- 30.4.7 Label all 11kV cables for their entire length as detailed in the Specification.

30.5 ELV Cable

30.5.1 To be developed with City University Operations Department.

30.6 Instrumentation / Control / SCADA Cable

30.6.1 Enclose all SCADA cables distributed in separate galvanised trunking, conduits as detailed in specification.

30.6.2 Check all SCADA cable types, specifications, terminations and wiring requirements with the SCADA Specialist during tender period and prior to placing orders or commencing works.

30.6.3 Make final connections to actuators, sensors and transducers, unless the cable is armoured, via flexible metallic, LSOH covered conduits, maximum length 500mm, size 10mm to 25mm as required. Where due to equipment entry hole size, direct entry is not practicable, make flexible conduit connection via sensor/transducer adaptors (RS Components supply or equal). Where neither of the above methods are applicable, compression glanded into equipment with any exposed cable protected with a nylon spiral wrap to afford some mechanical protection.

30.6.4 Devices supplied with flying leads must be terminated into a local terminal box adjacent to the device. (NOTE: This latter method applies only where the previous methods are impracticable and only then to extra low voltage signal cables for sensors and transducers).

30.6.5 Final flexible connections shall only be of sufficient length to allow the device to be withdrawn from the ductwork or pocket without the need to disconnect it.

30.6.6 Cables and flexible conduits shall be supported using metal or plastic clips using screwed fixings. Self adhesive fixings shall not be used for this purpose.

30.6.7 Where instruments are to be remotely sited from equipment, they shall be wall / frame mounted within polycarbonate enclosures to IP 55 with clear hinged fascia.

30.6.8 All SCADA cables shall be installed in cable trunking/conduit. Individual signal cables shall be clearly identified with Telemecanique DZ5 crimps and colour coded numbers (AR1-MC Range) in accordance with 'Trend' wiring schedules. Where multicore cable is used, the cable shall be identified with a marker.

30.6.9 Signal cable screens, braid, tape and/or armour shall be earthed at the outstation end only.

30.7 Cable Types / Specification

30.7.1 Type A- Motive Power for Actuators, Valves and Dampers

30.7.2 Single core, stranded, LSZH insulated copper conductor cable, 1.5mm² to the relevant Standards. Where multiple circuit runs occur within the SCADA trunking system positive and negative conductors of the same circuit shall be bound together at 3m intervals.

30.7.3 Type B-Field & MCC for Analogue and Digital Signal Cables



- 30.7.4 DEF - STAN 61-12 with foil and not braided screen. 2 core, 0.5mm² copper minimum conductor size as Anixter Ref.: A4-TO1-30024-09. For external applications use BS5308 One pair armoured.
- 30.7.5 Note - Where 4c requirements to one sensor, 2 x 2 core cables to be provided.
- 30.7.6 Type C-Communication Network Cable
- 30.7.7 BS5308 Two pair LSOH, individual screen, armoured, 0.75mm² 24/0.2 copper conductor.
- 30.7.8 Maximum wiring size to 2 part screw terminal connectors = 2.5mm², minimum size = 0.5mm².

30.8 Screening

- 30.8.1 Analogue inputs, digital inputs and analogue outputs. Screened cables to; DEF - STAN 61-12 (Part 5). Where indicated on the drawings any of these three types of signals may be mixed within the same multicore with one common screen.
- 30.8.2 Earth screen at transmission point only - so as to avoid earth loops.

30.9 Segregation

- 30.9.1 Group 1 - Analogue inputs, digital inputs, analogue outputs and communication cable.
- 30.9.2 Group 2 - Low voltage digital outputs (less than 30 volts).
- 30.9.3 Group 3 - High voltage digital outputs or other circuits.
- 30.9.4 Group 2 - Cables shall be run alongside Group 1 cables. But not with the same multicore.
- 30.9.5 Group 1 and 2 signals shall be segregated from Group 3 signal, by a minimum of:-
- 30.9.6 200mm for voltages of up to 250 volts
- 30.9.7 300mm for voltages of up to 500 volts
- 30.9.8 Segregation may be 20mm, where high voltage circuits steel wired armoured cables or other segregations are used including metal conduit.

30.10 Warning

- 30.10.1 Under no circumstances shall a megger or similar equipment be used when sensors, CNC devices, outstations or any other electric devices are connected. Should wiring require this level of testing all such devices shall be electrically disconnected from the equipment under test.

30.11 Communication Cable

- 30.11.1 To be developed with City University Operations Department.



30.12 Public Address Cabling

- 30.12.1 Install cabling on cable tray as detailed on the drawings with bushed end conduits fixed to soffit to support/contain cable from tray to ceiling positions.
- 30.12.2 Run cables to speakers from the tray, run in open conduits and tie wrapped to speaker supports dropping, when directly above the speaker.
- 30.12.3 All cabling to the loudspeakers to be 3 core 1.5mm² LS0H cable in accordance with the relevant Standards. Cable to have a white LSZH sheath.
- 30.12.4 Fully label circuits using proprietary cable markers at each termination.
- 30.12.5 Install and group the PA system wiring totally independent of all other circuits.

30.13 Data And Voice Cable

- 30.13.1 To be determined and agreed with City University Operations Department and IS.

30.14 Mineral Insulated Cables

- 30.14.1 Generally use 600v grade copper conductor MICC cable with LSZH overall sheath for all fire alarm and central battery emergency lighting wiring systems throughout, including all connections to interface units and between main and repeat panels where applicable. Use Belden Firetuf cable between FA panel and other connected systems.
- 30.14.2 Agree use of MICC cables for other applications with City University Operations Department.
- 30.14.3 Provide red overall sheathed cables to all fire alarm system installations and white overall sheathed cables to all central battery emergency lighting wiring systems.

30.15 Mineral Insulated Copper Covered and LSZH Sheath (MICC) Cables

- 30.15.1 Ensure mineral insulated cables have copper conductors, mineral insulation (inorganic type), copper sheathed, LSZH oversheath, and comply with the relevant Standards
- 30.15.2 600 Volt Grade for:
 - 30.15.3 Socket outlet circuits
 - 30.15.4 Lighting Point circuits
 - 30.15.5 Fire Alarm Systems
 - 30.15.6 Call Systems
 - 30.15.7 Reduced Low Voltage Systems



30.15.8 Unless otherwise specified in the following Section.

30.15.9 1000 Volt Grade for:

30.15.10 Motor Wiring

30.15.11 415 volt 3 or 4 wire circuits

30.15.12 Do not use cables less than 1.5 sq. mm in either voltage grade.

30.16 Terminations

30.16.1 Ensure the equipment for terminating MICC cables complies fully with relevant Standards and is of the same manufacture as that of the cable.

30.16.2 Ensure seals comply with the following:-

30.16.3 Installations up to 105°C - Cold screw-on pot seal with plastic compound, or alternatively shrink-on type using heat application.

30.16.4 Installations between 105°C and 185°C - Cold screw-on pot seal with suitable plastic compound and bonded glass-fibre caps, or alternatively, shrink-on type seal using heat application.

30.16.5 Ensure all terminations on surface installations have brass compression glands conforming to the relevant Standards. In areas where installations are concealed within the fabric of walls etc., use proprietary MICC clamps to the conduits/adaptable boxes.

30.16.6 Use of proprietary male/female cable gland arrangements where cables are terminated in plain hole boxes.

30.16.7 Insulate cable tails with sleeving to suit the prevailing temperature conditions and indicate phases.

30.16.8 Ensure live conductors have black sleeving and protective conductor tails green/yellow sleeving. Ensure phase conductors have a brown / red marker on the sleeve. Ensure sleeving is anchored and sealed to the pot.

30.16.9 Provide patent circuit protective conductor tails where glands are omitted with protective conductors brazed by the manufacturer to each pot and suitably sleeved.

30.16.10 Fit shrouds to terminations on all surface mounted LSOH sheathed mineral insulated copper covered cables.

30.16.11 Ensure all boxes used for terminating or jointing MICC cables are conduit boxes or Class 4, complying with the relevant Standards, and in accordance with the Specification.

30.17 Installation of MICC Cables

30.17.1 Ensure MICC cables are installed by tradesmen who have received a course of instruction on the handling, jointing and termination of MICC cables.

- 30.17.2 Ensure the tradesmen are also fully instructed in the use of the specialist tools recommended by the manufacturer, which are to be used on the installation.
- 30.17.3 Secure cables by means of LSOH served copper saddles using 30mm x No.8 roundhead brass fixing screws. Use multiple saddles where several cables are installed together. Install MICC cables on cable tray in accordance with the Specification, where two or more cables are installed together.
- 30.17.4 Ensure the maximum spacing of fixings are:-
- 30.17.5 Overall diameter of MICS Cable - Horizontal/Vertical
- 30.17.6 Up to 9mm - 600mm/800mm
- 30.17.7 Above 9mm and up to 15mm - 900mm/1200mm
- 30.17.8 Above 15mm and up to 20mm - 1500mm/2000mm
- 30.17.9 Ensure where unserved cables are specified, the saddles are made of copper.
- 30.17.10 Protect MICC cable to full height by a metallic cover when rising on the surface from the floor.
- 30.17.11 Protect MICC cables by means of galvanised metal capping where concealed in walls.
- 30.17.12 Ensure that where surface mounted equipment is installed on a concealed MICC installation the cables terminate in a flush mounted circular box, and the back of the equipment is drilled and bushed for back entry. Then install the equipment over to conceal the box.
- 30.17.13 Ensure cables are installed neatly on the surface and routes are truly horizontal, vertical or parallel with the features of the building.
- 30.17.14 Ensure that the routes of cables laid in floor screeds are carefully planned to avoid areas where there is a possibility of floor fixings. Avoid centres and edges of doorways to allow for fixing closure bolts etc.
- 30.17.15 Ensure that cable crossings in floor screeds are kept to a minimum and maintain a screed cover of 25 mm above cables.
- 30.17.16 Ensure that MICC cables fixed to galvanised cable tray are LSZH sheathed. Fix saddles using brass roundhead screws, washers and nuts.
- 30.17.17 Make connections to items of equipment subject to vibration, adjustment, or withdrawal by terminating the cables in an appropriate adaptable box, sited adjacent to the item being connected, and enclose the final connection from the box in metallic flexible conduit or install a 360° loop not less than 150 mm diameter immediately adjacent to the cable entry to the equipment. Allow a clear space of not less than 10 mm at the point where the cable crosses itself.
- 30.17.18 Test all MICC cable seals for insulation resistance on completion of the seals at both ends of the cable within 24 hours after completion and ensure the test proves an infinity reading using a 500 volt d.c. test.



- 30.17.19 Ensure all cables are neatly installed, straightened and suitably dressed with rollers etc., to give a neat and workmanlike installation.
- 30.17.20 At termination positions, arrange cable conductors to minimise crossing.
- 30.17.21 Fit surge suppressers to all cable ends connected to motors with star connection up to and including 2kW size.

31 CABLE TERMINATION AND JOINTING

- 31.1.1 Ensure all joints and terminations comply with the relevant Standards, and cable and accessory manufacturers recommendations.
- 31.1.2 Carry out all cable terminations and cable jointing in accordance with the requirements detailed in the Specification, where applicable for each cable type and specification.
- 31.1.3 Ensure switchgear, isolators and distribution boards, etc., have terminals to receive bolt-on lugs, and that all switchgear, isolators and distribution boards etc., have provision and facilities (e.g. cable extension boxes) to accept cable size, type and quantity of cables indicated in the specification on drawing for the particular project requirements.
- 31.1.4 Ensure all bolted terminations have suitable bolts, nuts and shakeproof washers and have been adjusted to the correct torque.
- 31.1.5 Joint the core of low voltage cables colour-to- colour or number-to-number, as appropriate. Ensure cores which are identified by numbers are connected so that:-
 - 31.1.5.1 'O' is neutral in any multicore cable.
 - 31.1.5.2 '1' is brown or red phase in any 3 or 4 core or the phase conductor in a 2-core cable.
 - 31.1.5.3 '2' is black or yellow phase in a 3 or 4 core cable.
 - 31.1.5.4 '3' is grey or blue phase in a 3 or 4 core cable.
- 31.1.6 Terminate all lighting points in a Flex 7 box mounted flush to ceiling. Ensure the box is heavy gauge self extinguishing PVC to the relevant BS reinforced with tapped metal inserts.
- 31.1.7 Ensure cables in roof spaces are clipped to the sides of joists and where traversing joists, provide and fix binder joists or suitable battens
- 31.1.8 Ensure all cables are neatly installed, dressed to give a neat and workmanlike installation.

31.2 Underground Cabling

- 31.2.1 Provide design and/or installation of underground cables in accordance with the drawings incorporated in the Specification.
- 31.2.2 Generally builders works including trench digging, backfilling, ducts and draw pits, protective tiles, marker tape, marker posts, drawcords and duct sealing will be provided by a Builder. In conjunction with the builders work allow for liaison with the Builder to ensure that trenches are of the correct depth, backfilling is carried out correctly and ducts are suitably laid, identified, routed and made good.
- 31.2.3 Provide in design and/or installation for segregation of all underground cable and wiring types and systems in accordance with all relevant Regulations, Standards and Codes etc.
- 31.2.4 Identify and locate any existing below ground services or obstructions prior to designing or installing underground cable routes, locations and arrangements.

- 31.2.5 Identify requirement for ducts, concrete encasement or pipe sleeves etc. Where cables run under roadways, concrete hardstanding, buildings, ensure ducts and/or cable ways identified, are adequately sized to suit cable installation requirements and include a minimum of 30% spare ducts for future cables. Duct internal diameter to be not less than 12.7 times the cable diameter.

31.3 Direct Buried Cable

- 31.3.1 Ensure minimum cover from the general finished ground level at contract completion of 800mm for HV cables and 600mm for LV and other cables. Bed cables on 75mm of sifted sand, then cover with a further 75mm of sand. Lay interlocking cable cover tiles, for HV cables or yellow Warning Tape with stainless steel tracer wire for other cables before backfilling the trench with earth sieved through a 12mm mesh.
- 31.3.2 Ensure depth of cable trenches is adequate to provide the minimum specified depth of cover above cables. Lay tiles above cables after the sifted sand over cables, as specified, has been applied.
- 31.3.3 Ensure cables are routed through ducts laid 750mm minimum below finished ground level, for all road, drive and car park crossings.
- 31.3.4 Install two layers of permanently coloured yellow PVC tape marked "ELECTRIC CABLE BELOW - CAUTION" 150mm wide with stainless steel tracer along the entire length of the cable. Place the lower layer 50mm above the cable and the higher layer 100mm below the finished ground level.
- 31.3.5 Ensure backfilling does not contain stone, brick, or sharp material and is fully consolidated with a rammer to the level before laying the second tape. Carry out the final backfill to ground level and suitably consolidate.
- 31.3.6 Set concrete marker slabs or posts into the finished ground surface above the cables at 45 metres spacing and at all changes of direction, joints, road crossing etc. Fit proprietary concrete markers with 'Electric Cables' deeply engraved, with plastic inserts also indicating the depth and voltage of the cable(s).
- 31.3.7 Install cable markers level with the finished surface.
- 31.3.8 Ensure the depths specified are to the top of the any conduit, ducts or sleeves.
- 31.3.9 Ensure where more than one power cable of the same voltage system follows the same route, a minimum spacing of 50mm is maintained between them. Where HV and LV power cables follow the same route, ensure separation by a horizontal distance of at least 300mm. If buried cables for communications and alarms follow the same route, ensure separation by a horizontal distance of at least 300mm from the power cables.
- 31.3.10 Separate all buried cables from piped services by at least 300mm.
- 31.3.11 Where buried cables enter buildings fix a brass plate to the wall above each cable 300mm above finished ground level. engraved with the following information:-
- Destination (or source) of cable, e.g. BOILER HOUSE
 - Type of cable e.g. LS0H/SWA/LS0H
 - Number, size and material of conductors e.g. 4C 120mm Cu

31.4 Cables in Underground Ducts

- 31.4.1 Ensure drawpits are in general in accordance with the requirements detailed by City University Operations Department and / or in the Specification, and of adequate size for pulling, handling and bending of the cables. Provide draw pits at maximum spacings between each other of 50m for straight cable routes, and elsewhere at changes in direction and at building entry positions where agreed with City University Operations Department. Ensure ducts leaving drawpits are bell mouthed, suitably positioned and aligned for ease of pulling cables. Ducts to be twin wall polyethylene with a smooth bore and corrugated externally or smooth bore vitrified clay.
- 31.4.2 Ensure drawpits have a base and foundation of concrete with 225mm thick walls of class B engineering bricks. Provide Elkington Gatic easily removable covers over the whole drawpit. Ensure the covers fit in watertight seatings set in concrete. Incorporate holes for lifting keys.
- 31.4.3 Locate drawpits generally off roadways or parking areas. If drawpits must be located where vehicles have access, provide the covers of suitable strength.
- 31.4.4 Where cables require supporting within a drawpit, this may be achieved by means of a low brick wall within the drawpit or by galvanised steel channel across the drawpit.
- 31.4.5 Where ducts enter the foundations of buildings, start the ducts at least 1 metre from the outside edge of the foundations. Where a cable is required to rise vertically into the building interior, ensure the duct rises with such a radius as to enable ease of cable pulling. Ensure the mouth of the duct is flush with a vertical wall, where appropriate, to enable the cable to be fixed against the wall at floor level. Provide puddle flanges, where appropriate, with duct entry points entering into below ground level areas and foundations etc.
- 31.4.6 For large cables, provide pits instead of bends in ducts.
- 31.4.7 Before installing cables, clear ducts of any obstructions liable to damage the cables. Separate each power cable into a separate duct, unless specified otherwise.

31.4 It is essential that ducts into buildings are sealed. Flood control measures must not be compromised

- 31.4.1 Seal ducts ends around the cable with suitable mastic material, split plugs/bungs or foam. Seal spare ducts. Leave draw cords in the spare ducts.
- 31.4.2 Seal all ends of conduit around the cable with waterproof and gasproof seal of self-extinguishing plastic foam of an approved type.
- 31.4.3 Ensure any spare cable conduit have suitable end caps.
- 31.4.4 Install cables to be pulled in underground ducts by hand. If machines are used, fit with torque limiters, set to ensure the cable manufacturers maximum pull torque, is not exceeded.
- 31.4.5 Achieve pulling in by use of stocking pulling grip. Maximum stress not to exceed manufacturer's recommendations at any time. (Submit manufacturer's details prior to commencement of any cable installations).

- 31.4.6 Ensure cables do not cross each other in trenches, except at branches from main trenches.
- 31.4.7 Fit all cables, where in draw pits or accessible trenches/ducts, with lead identification bands at entry and exit points and at all points where they enter ducts or road crossings below ground level, etc.
- 31.4.8 For small communications and alarm cables plastic pipe may be used for ducting.

31.5 Cable Fixings

- 31.5.1 Where appropriate securely install all cable/fixing and containment components to the building fabric using any of the following methods:-
 - 31.5.1.1 Expanding bolts such as "Redheads" and Rawlbolts" or similar for heavy loads fixed to masonry or concrete.
 - 31.5.1.2 White metal or plastic wall plugs and screws for light loads to masonry or concrete.
 - 31.5.1.3 Screws into wood for light fixings.
 - 31.5.1.4 Clamps and adaptors to fix to structural steelwork, if approved by City University Operations Department and the appointed Structural Engineer in writing.
 - 31.5.1.5 Proprietary adaptors for proprietary cast in fixings when provided as part of the building.
- 31.5.2 All fixings shall be employed within the loading recommendations of the manufacturers.
- 31.5.3 Fixing Methods Not Allowed
 - 31.5.3.1 Drilling structural steelwork.
 - 31.5.3.2 Hanging supports with loose back plates under floor screed.
 - 31.5.3.3 Wooden or fibre wall plugs.
 - 31.5.3.4 Built-in fixings unless specifically detailed by City University Operations Department.

31.6 Explosive Type Fixing

- 31.6.1 Fixings using explosives would require the City University Operations Department or their appointed Structural Engineers or representatives written approval in advance and would only be allowed for light fixings.

31.7 Holes for Fixings

- 31.7.1 Drill all holes required for fixings.
- 31.7.2 Provide and complete all necessary support steelwork, brackets and suspension threaded rod etc. to support the electrical installation defined in the Specification and shown on the particular project drawings.

- 31.7.3 Paint all support steelwork erected to suit the class of installation i.e. standard paint finish (Class 2) for non-surface/interior areas and galvanised finish (Class 4) for surface and exterior areas unless otherwise defined in the Particular Project Specification.
- 31.7.4 Do not fix electrical services to the mechanical services support steelwork where it is subjected to vibration or heat transfer.
- 31.7.5 Implement co-ordination of the services from the outset of the contract with all other Installers and if necessary, identify as an item, on the contract programme of work.
- 31.7.6 Do not support electrical services from any suspended ceiling system, but provide with independent support fixings, unless otherwise stated on the particular project drawings.

31.8 Expansion Joints

- 31.8.1 Supply and install complete, all necessary expansion joint units for services such as conduit, tray, trunking etc., where these cross vertical and horizontal building expansion joints.
- 31.8.2 Ensure each unit is of a recognised pattern supplied by the appropriate service manufacturer.
- 31.8.3 Where cables cross expansion joints, clamp loosely within the respective fixing saddles/cleat to allow movement and in extreme cases install formed loops.

31.9 Cable Ladder

- 31.9.1 Use cable ladder/rack and manufactured bends, tees etc. only when indicated for particular project requirements.
- 31.9.2 Install cable ladder generally in accordance with requirements for cable tray installations indicated in the Specification.
- 31.9.3 Do not site fabricate joints or bends.

31.10 Cable Trays

- 31.10.1 Ensure cable trays are perforated sheet steel and hot dip galvanised to the relevant Standards, and formed with returned flange.
- 31.10.2 Use medium duty tray internally.
- 31.10.3 Use heavy duty tray externally.
- 31.10.4 Design and/or install stainless steel or GRP type cable tray systems only for particular project requirements agreed with City University Operations Department.
- 31.10.5 Design and install cable trays sizes with 30% spare capacity for future cables.
- 31.10.6 Take care to avoid any electrolytic action between dissimilar metals. Never allow any copper cable sheath or fitting to be in contact with the galvanising.

- 31.10.7 Generally ensure cables are LSZH served. Where cables have no serving then lay these on a layer of LS0H material securely fixed to the tray.
- 31.10.8 Use standard manufacturer's fittings. If local situations make it impracticable fabricated fittings may be accepted by City University Operations Department provided they are of the same quality and protective finish.
- 31.10.9 Ensure sets and bends are sized to allow for the minimum permissible radius of the largest cable on the tray. Ensure cables shall retain their relative positions on all bends and sweeps.
- 31.10.10 Maintain earth continuity at all joints with suitable earthing links. Ensure joints have all burrs removed and are made by fishplates and screws.
- 31.10.11 Provide protective grommets through all cut holes in the body of the tray.

31.11 Installation of Cable Tray

- 31.11.1 Route cable tray to cause the minimum amount of obstruction. Position to minimise build-up of dust/dirt on cables. Run cables with regard to neatness of appearance and arrange multiple runs so that cables entering or leaving the run do so in a logical manner with minimum cross overs.
- 31.11.2 Allow 25mm minimum space between the tray and fixing medium to give ease for securing the cable fixings and general maintenance.
- 31.11.3 Install cable trays on mild steel supports with galvanised or painted protective coating, fixed to the structure at not more than 1 metre intervals, or at such spacing to ensure a maximum deflection of 5 mm when loaded. Use fixings of expanding masonry bolts or equal. Alternatively, use proprietary galvanised steel channel permitting easy adjustment and modification. Proprietary clamp fixings on to the flanges of structural beams are also permitted.
- 31.11.4 Prime and paint all bare metalwork, fixing bolts etc., with two coats of zinc enriched paint.
- 31.11.5 Achieve joints in sections of cable tray and fixing of tray to support brackets, by means of sheradised mushroom headed bolts and nuts, with the threaded portion away from the cables.
- 31.11.6 Ensure all cable clamp/cleat fixing bolts/studs are sherardized and where forming part of the design, of sufficient length to allow stacking of cables, and in accordance with the Specification requirements.
- 31.11.7 Power and control cables may be run on a common tray, providing the cable voltage rating is identical. Provide separate cable tray systems for specialist installations e.g. communications, fire alarms, instrumentation etc., as indicated in the Specification and/or on the particular project drawings.
- 31.11.8 Obtain approval of the route and fixing methods before erecting cable tray.
- 31.11.9 Design and install power cables to be laid in a maximum of two layers. Allow for correction factors incorporated in the design.
- 31.11.10 Provide cable fixings to tray as cleats, clips or multiway saddles of LS0H covered metal strip, depending upon the type and size of cables.



- 31.11.11 Do not use PVC tie wraps, unless prior agreed by City University Operations Department.
- 31.11.12 Apply plastic protective edging to any metal edges which cables cross.
- 31.11.13 Bond each run of cable tray to earth at the point nearest to the main power intake to the system and test for earth continuity at the remote end.
- 31.11.14 Where cable trays are installed across expansion joints in buildings and service ducts etc. fit a proprietary slip connector fixed at one end only, and with flexible earth bonds.

31.12 Cable Trunking

- 31.12.1 Ensure all cable trunking and accessories are of approved type and manufacture. Select all connections, bends and sets from the approved manufacturers' range of accessories. Obtain written approval from City University Operations Department for the use of non-metallic trunking.
- 31.12.2 Ensure all fixed bolts for accessories and brackets, etc., are of the round head type fitted with heads within the trunking and cut to exact length of accommodate nuts.
- 31.12.3 Install trunking routes neatly on the surface truly vertical, horizontal, or parallel with the features of the building.
- 31.12.4 Size the trunking in accordance with the relevant Standards.
- 31.12.5 Install additional spring straps to separate cables in trunking of 100 mm or larger. Avoid bunching of cables in the bottom of the trunking. Use multi-compartment trunking where segregation of cables is required. Fit internal separation fillets where applicable to the full depth of the trunking so as to give complete segregation.
- 31.12.6 Install trunking with lid on top or side. "Install" removable cable restraining straps into trunking at 600mm (maximum) intervals where trunking covers are fixed on the side of trunking, or in vertical runs.
- 31.12.7 Do not pass conduits through the trunking body to serve a particular compartment. Connect conduits to the respective compartments externally using appropriate boxes.
- 31.12.8 The situations where tees and junctions are to be installed use multi-compartment fittings of such depth as to ensure suitable passover connections.
- 31.12.9 Ensure where skirting, dado or bench trunking is specified, all necessary sets round columns and floor links across doorways are provided.
- 31.12.10 Ensure where trunking is to be fixed to plastered walls, it is installed in cooperation with the builder to avoid gaps between wall and trunking.
- 31.12.11 Install all underfloor/flush floor trunking systems where required complete with segregated compartments, fixed straight and level and to suit the finished floor level, and in accordance with the selected manufacturer's installation instructions.
- 31.12.12 Ensure where cable trunking of the type used to suspend lighting fittings is employed, the manufacturers recommendations for fixing centres, loading etc., are in no instance exceeded.

- 31.12.13 Keep all trunking free of debris during and after installation.
- 31.12.14 Do not use trunking to support equipment linked to it.
- 31.12.15 Install heat barriers in vertical routes of trunking of 5m or more internal fire barriers when passing through floors or fire compartment walls, cavity barriers etc. Ensure heat barriers do not contain asbestos and are of manufacturers proprietary type.
- 31.12.16 Install insulated pin racks supporting cables in vertical lengths exceeding 3m, with pin rack maximum centres of 2m.
- 31.12.17 Install drip proof, close fitting, easily removable trunking covers along the complete trunking length. Ensure trunking covers are of the same material and protective finish as the trunking.
- 31.12.18 Do not use self-tapping screws or fixed bridge pieces to hold the cover in position.
- 31.12.19 Fix trunking securely at intervals not exceeding that set out in the relevant Standards.
- 31.12.20 Use manufacturer's standard fittings only. Non Standard fittings, where necessary will be accepted only with the agreement of City University Operations Department.
- 31.12.21 Ensure all fittings are of the same material and protective finish as the trunking.
- 31.12.22 Make connections to distribution boards, equipment, panels etc., by using manufactured flanges giving the full trunking capacity, making due allowance for the future installation of cables from spare ways. Fit appropriate gaskets between the flange and board etc. to maintain I.P. rating.
- 31.12.23 Ensure covers are removable over the whole length of the trunking. Where trunking passes through walls and ceilings, provide a short length of fixed cover to form a sleeve for 25mm on each side.
- 31.12.24 Where flush trunking is used, install flush-type covers and ensure the finished edge of the trunking is flush with the fabric of the building.
- 31.12.25 Suspensions or fixings must not intrude into the internal space. Use roundhead screws for joining to suspension or fixings. Remove any burrs to the head of the screw.
- 31.12.26 At construction expansion joints provide the trunking with a sliding coupling complete with a flexible protective conductor ensuring equipotential bonding, where applicable.
- 31.12.27 Give due allowance for expansion to all fixings and connections as recommended by the manufacturer.
- 31.12.28 Do not use trunking in exterior locations, unless of a proprietary type, and only in instances agreed with City University Operations Department.
- 31.12.29 Prior to installing cables in trunking remove all debris and take precautions to prevent further ingress of debris.
- 31.12.30 For all changes of direction, terminations, tees, use the manufacturer's fittings and suitably gusset bends and tees for the largest cables.



- 31.12.31 Do not use site fabricated fittings unless the situations encountered make the use of manufactured fittings impracticable. In such cases seek the agreement of City University Operations Department and submit sample site-fabricated trunking for consideration.
- 31.12.32 Include provision for the integrity of the fire barriers through which cable trunkings, are being installed by making good around the installations with appropriate fire stopping materials. Carry out this work to the requirements of Building Regulations and those of the relevant Standards.

31.13 Metallic Cable Trunking

- 31.13.1 Ensure manufacture of all metal cable trunking is from sheet steel in accordance with the relevant Standards.
- 31.13.2 Provide finish of either zinc coated sheet steel or galvanised to suit the associated conduit systems or as indicated for the particular project requirements.
- 31.13.3 Supply the trunking in standard lengths, free from all sharp edges and projections with each length including a coupling sleeve. Ensure the trunking body has inturned flanges. Provide steel lids of the same finish, secured with mushroom headed screws.
- 31.13.4 To protect against corrosion use stove enamel or "Zintec" inside and outside in Class 2 areas, and hot dip zinc coating in Class 4 areas.
- 31.13.5 Ensure trunking routes are mechanically and electrically continuous throughout their length. Fit brass continuity links to all trunking joints exterior to the trunking, use brass bolts and shake-proof washers.
- 31.13.6 Provide copper earth bonding links between lengths of trunking irrespective of whether a separate earth conductor is run through the trunking.
- 31.13.7 Remove paint from the trunking where the bonding links are fitted.
- 31.13.8 Ensure junctions between trunking and equipment use the following alternative methods:-
- 31.13.8.1 Surface conduit as detailed in the Specification.
- 31.13.8.2 To recessed conduit via a flush circular box behind the trunking with a bushed hole in the back of the trunking and an insulated earth wire from the trunking earth bonding screw to the circular box earth terminal.
- 31.13.8.3 To a surface box, switch, starter etc. by a single connection comprised of male brass bush, shakeproof or compression washer, coupling, shakeproof or compression washer and brass male bush.
- 31.13.8.4 To a distribution board, control panel, large switch enclosure, etc. a single connection consisting of matching holes, cut in the trunking and enclosure, a spacer of traffolyte or insulating material not less than 6mm thick with a hole slightly smaller than the holes in the metalwork, fixing screws and nuts and separate copper strip earth connection between the trunking and enclosure.
- 31.13.8.5 To an enclosure on the end of a trunking by a flange unit with suitable cabled protection of the edges of the hole in the enclosure and separate copper strip earth connection.

- 31.13.9 Other methods may be considered for approval by City University Operations Department.
- 31.13.10 Make connections between trunking and equipment by means of a brass male bush, coupling and internally serrated washer, or a standard flanged coupling.
- 31.13.11 Where trunking is cut to receive flanges etc. protect the cut edges of the trunking with a suitable material to prevent damage to wiring.
- 31.13.12 For floor metallic cable trunking installations install complete appropriate floor service outlet boxes, junction and change of direction boxes, vertical intersection boxes to form a complete installation.
- 31.13.13 Install all floor boxes of the fully adjustable pattern fitted with the required segregated compartments, with appropriate lids.
- 31.13.14 Install, power data and telephone outlets as required.
- 31.13.15 Where trunking is to be laid in floor screeds ensure that no void occurs below trunking lengths and that the routes/boxes are correctly packed. Take precautions to prevent the ingress of screed or debris into the trunking system.
- 31.13.16 Ensure that all floor trunking level alignment is correct and the desired level is maintained throughout the screed laying process.
- 31.13.17 Ensure that the underfloor trunking systems are fully rewirable to all final service outlets. Where wireways only are required then include draw-in wires to suit the particular system(s).

31.14 Non-Metallic Dado Cable Trunking

- 31.14.1 Generally non-metallic trunking shall be Marshall Tuflex Sterling Range.
- 31.14.2 Ensure that non-metallic cable trunking complies with the relevant Standards with the Specification requirements for metallic trunking where applicable, and is of heavy gauge high impact quality, self-extinguishing extruded PVC compound. Ensure the trunking is smooth inside and outside and fitted with drip-proof lids.
- 31.14.3 Do not use non-metallic trunking for vertical routes of 5m or more where heat barriers are required in a manner to prevent high temperature rise; use appropriate metallic trunking.
- 31.14.4 Do not insert non-metallic trunking in fire compartment walls, or pass through floors. Use metal trunking of the correct classification in these instances with a short length of cover to form a sleeve. Ensure the cover of non-metallic trunking is removable throughout.
- 31.14.5 Make connections to distribution boards by flanges giving the full trunking capacity. Cement the flange to the trunking. Install an appropriate gasket between flange and board to maintain I.P. rating of the board etc.

31.15 Cable Basket

- 31.15.1 Provide cable basket type wire containment systems where required for each particular project and in agreement with City University Operations Department.



- 31.15.2 Ensure cable basket installation is approved proprietary manufacturers system incorporating all matching accessories, components, fixings and mountings devices.
- 31.15.3 Install cable basket system in accordance with manufacturers recommendations and requirements.
- 31.15.4 Use cable basket system for containment of data and communication type cable installations only and/or where agreed with City University Operations Department.
- 31.15.5 Ensure cable basket system is rigidly fixed and located for easy access throughout its length and erected to allow satisfactory laying in of cables, and for fixing cable in both horizontal and vertical runs. Space basket system from building surfaces and structures by a minimum of 25mm to allow cable tie fixings to be carried out.

31.16 Conduit Systems

- 31.16.1 Do not use conduit less than 20mm diameter.
- 31.16.2 Carry out all conduit work, whether surface or concealed, in accordance with sound practice and in a workmanlike manner using skilled Tradesmen.
- 31.16.3 Ensure conduits are surface or concealed as detailed in the Particular Project Specification and/or on the drawings.
- 31.16.4 Size all conduits so as to comply with the relevant Standards.
- 31.16.5 Take care with the appearance of the installations. Install all accessories, adaptable boxes, draw-in boxes, etc., "square".
- 31.16.6 Install inspection boxes in accessible positions giving due regard to switch and socket positions and any aesthetic requirements.
- 31.16.7 Take special care to prevent dirt and moisture entering conduit/installations. Do not leave ends of conduits open during building operations.
- 31.16.8 Space conduits at least 150mm from other services, i.e. gas, water, steam, etc. and where this minimum spacing cannot be achieved, then cross bond at least once per room, where applicable.
- 31.16.9 Do not use more than two right-angled bends, or longer than a 10m length of conduit between draw-in boxes.
- 31.16.10 Do not use elbows or tees unless agreed with City University Operations Department.
- 31.16.11 For the purposes of this Specification, a double-set constitutes the equivalent of 1 no. right-angled bend.
- 31.16.12 Do not draw in cables until all the sections of the conduit installation are complete.
- 31.16.13 Draw in cables in a careful and workmanlike manner. "Comb" cables as drawing-in proceeds and lay the neutral and protective conductors of each circuit with each phase cable of that circuit.

- 31.16.14 In multiple conduit installations, do not cross conduits.
- 31.16.15 Where a surface conduit turns through a wall install a back outlet box.
- 31.16.16 Take care in the appearance of the installation. Ensure all accessories, adaptable boxes, draw-in boxes, etc., are truly square.
- 31.16.17 Support each bend set, adaptable box, and conduit box, at 150mm (maximum) on each side, equally spaced.
- 31.16.18 In areas where there is danger of condensation, fill boxes with a moisture repelling compound.
- 31.16.19 Ensure all conduit work is drained, cleared, and swabbed before wiring is carried out.
- 31.16.20 Install boxes of the 'terminal', 'through', 'tee', or 'crossing' circular patterns for all lighting points.
- 31.16.21 In other cases use metal boxes of malleable iron or heavy duty steel with welded joints. Ensure steel boxes have lugs suitably tapped to receive brass cover fixing screws (not self-tapping). Provide covers for each box unless an accessory or fitting is mounted over.
- 31.16.22 Ensure boxes in exterior locations, or subject to continual dampness, have external fixing lugs.
- 31.16.23 Ensure conduit boxes have terminal blocks supplied and fixed where used as junction boxes with permissible cable joints, where agreed with City University Operations Department. Ensure terminal blocks have brass connectors shrouded in porcelain or heat resisting material capable of withstanding, without deterioration, the same temperatures as the pots, insulation and sleeving. Ensure the box is of a size to allow for the terminal block and to facilitate neat connections.
- 31.16.24 Ensure all conduits, accessories, or adaptable boxes, to which flexible cables, or flexible conduits are fitted, or upon which accessories or equipment are mounted, have earthing terminals provided and are securely fixed to the box.
- 31.16.25 Secure saddles and boxes by screws of a minimum size of 30mm x No.8.
- 31.16.26 Use approved masonry fixing devices. Do not use wood or fibre plugs. Make holes neatly in masonry with a masonry drill of the correct size for the device being used.
- 31.16.27 Drill and tap holes in metalwork using 6 mm diameter metal thread screws.
- 31.16.28 Where the items to be fixed have countersunk holes, use countersunk screws ; use roundhead screws in all other cases.
- 31.16.29 Ensure that accessory boxes are surely fixed using a minimum of 2-No. fixings.
- 31.16.30 Use shot-fired fixings only with the prior approval of City University Operations Department.
- 31.16.31 Unless otherwise defined in the Particular Project Specification on the drawings, or agreed with City University Operations Department, use only proprietary fixings for conduct to structural steelwork, such as 'clamps', 'rod clips' etc.

31.17 Metallic Conduit and Fittings



Protection Against Corrosion

- 31.17.1 Ensure conduit Systems comply with the relevant Standards are of the heavy gauge welded and screw pattern. Ensure conduit systems are mechanically and electrically continuous throughout. Ensure the class of protective finish is as follows:-
- 31.17.2 Class 2 - Medium protection, stoved black enamel or air drying paint both inside and outside apply to the general installation work in locations where Class 4 protection is not required.
- 31.17.3 Class 4 - Heavy protection, and hot dip zinc/galvanised coated or sheradised both inside and outside. Design and/or install stainless steel conduit systems only under special circumstances for particular project requirements and in all cases agreed with City University Operations Department.
- 31.17.4 Areas deemed to be included as Class 4 areas (unless indicated in the Particular Project Specification) are:- Kitchens; Plant Rooms; Tank Rooms; Lift Shafts and Motor Rooms; Service Tunnels in Ducts buried in ground; external and internal areas subject to dampness in normal service.
- 31.17.5 In these instances and where the installation is mounted outside a building, or in situations of continual dampness, ensure hot dip galvanised finish conduit boxes have external fixing lugs with malleable iron covers and mating machined surfaces and where necessary appropriate neoprene gaskets.
- 31.17.6 Ensure the protective coatings on conduits and fittings are the same class.
- 31.17.7 Use black enamelled conduit systems in dry locations and where the conduits are to be buried in floor screeds and wall plaster, but where the project programming necessitates erection of conduit systems before the building is weatherproof, galvanised conduit and fittings shall be used.

31.18 Metallic Conduit

- 31.18.1 Thread conduits to the correct length and ream at both ends. Clean off all lubricants and swarf. Clean existing threads using appropriate running dies before installation.
- 31.18.2 Ensure all conduits and fittings are free from defects and rust on delivery to site. Store in covered racking properly protected from any damage or weather.
- 31.18.3 Replace conduits where the protective coating is damaged, or where the protective coating becomes damaged after, before, during or installation. Make good the rust patches by cleaning down to bright metal, priming and re-painting to match the existing, to the satisfaction of City University Operations Department.

31.19 Metallic Conduit Fittings

- 31.19.1 Ensure all fittings are malleable iron conforming to the relevant Standards.

Saddles:

- 31.19.2 Ensure Class 2 protective areas have spacer bar type saddles with 3mm clearance between the conduit and fixing surface.



31.19.3 Ensure Class 4 protection areas have distance spacing type saddles with 12mm clearance between the conduit and fixing surface. Ensure brass fixing screws are used in Class 4 areas.

Conduit Boxes:

31.19.4 Ensure Class 2 protection areas have conduit boxes complying with the Specification.

31.19.5 Ensure circular malleable iron for all draw-in boxes, lighting points, angle boxes, tee boxes, and any junction up to four conduits. In all other cases use adaptable boxes of the appropriate protective finish.

31.19.6 Ensure all boxes, have heavy steel covers fixed with brass screws, except where covered with a direct mounting accessory or fitting.

31.19.7 Ensure covers are oversized where used as flush inspection points and with break joint rings at luminaire and ceiling switch positions. Ensure conduit boxes, with the exception of loop-in boxes, are spout entry, standard or deep pattern.

31.19.8 Ensure loop-in boxes are of the non-screwed entry type.

31.19.9 Ensure conduit boxes in Class 4 protection areas are hot dip galvanised finish.

Adaptable Boxes:

31.19.10 Ensure fittings comply to the relevant Standards and are made of malleable iron or heavy duty steel with welded joints and tapped lugs to receive the cover screws. Ensure boxes have the same protective coating as the conduit installation.

31.19.11 Where used in a Class 4 installation, in exterior locations, or in areas of continual dampness, ensure that adaptable boxes have external lugs and a waterproofing seal between the box and the cover. In other Class 4 areas external lugs are not required.

31.19.12 Ensure that where provided as junction boxes with permissible cable joints, the adaptable boxes are of adequate size to receive a din rail mounted heat resisting terminal block capable of withstanding the same temperatures as the cable insulation.

31.19.13 Allow for cable sweeps and neat connections.

31.19.14 Install the terminal blocks securely fixed to the box, using sealing washers in exterior locations or in areas of continual dampness.

31.19.15 Where necessary, provide adaptable boxes with earthed barriers to segregate services.

31.19.16 Provide overlap lids on flush installations.

Bushes:

31.19.17 Use only brass, male type, long threaded bushes where loop-in and non-screwed entries are provided. Do not use lock nuts and ring bushes.

Couplings:



31.19.18 Ensure couplings comply with the relevant Standards with protection against corrosion, as applicable.

Earthing Terminals:

31.19.19 Provide earthing terminals securely fixed to the box on all equipment boxes, conduit accessories and adaptable boxes to which cables or flexible conduits are fitted, or to boxes upon which accessories or equipment are mounted.

Serrated Washers:

31.19.20 Use spring metal, female type.

31.19.21 Cut all conduit threads "square" to the correct length and properly butt. Do not allow exposed threads, except on running couplings. Ream all ends smooth.

31.19.22 Where conduits are connected to trunking, metallic boxes, panels, switchgear, or any item not having a tapped entry (or a tapped entry of 6mm or less), make the connections by long threaded male brass bushes with a coupling and serrated spring washer after removing the paint with a purpose made tool.

31.19.23 Tighten bushes with a tool specifically designed for that purpose - do not use pliers or toothed wrenches.

31.19.24 Use locknuts with running couplings in Class 2 areas.

31.19.25 During building operations plug and coat ends with petroleum jelly. Use only screwed caps or shaped plugs.

31.19.26 Similarly protect conduit entries to all boxes by shaped plugs.

31.19.27 Form all easy sweep bends on a proprietary bending machine. Do not use 'site' manufactured bends, elbow or tee components or U-bends. The radii of 'pulled' bends shall be as defined in the relevant Standards.

31.19.28 Ensure all screwed connections are metal and watertight. Ensure in all cases conduit is screwed firmly into fittings, full use being made of the total length of thread. Where runners or similar type threaded connections are essential, heavy gauge hexagonal locknuts must be fitted and fully tightened. The ends of fittings, sockets, etc. in such cases to be machine finished to permit accurate contact and alignment.

31.19.29 Make joints between conduits and accessories or equipment not having threaded spout entries by means of flanged couplings and hexagonal smooth bore male brass bushes. Ensure the bore of the bush to be not less than that of the conduit with which it is connected. Ensure clearance holes in accessories and equipment are accurately drilled and of correct size to accept the hexagonal bush. The use of knock-out boxes will not be permitted without prior approval of City University Operations Department in each and every instance.

- 31.19.30 Provide all lighting points, socket outlets, equipment points, etc., with a suitable box securely fixed to the building fabric, which is able to support the weight of the fittings etc. The box can be the housing of the accessory or equipment provided it is metal with conduit entry.
- 31.19.31 Use graphite paste for lubrication.
- 31.19.32 Immediately after installation make good all conduits and fittings with any damage to finish; remove all rust, brush to bright metal, and prime and paint to match the existing finish. Similarly treat all exposed threads (only permissible at running joints) and all bush and coupling joints. In Class 4 areas, effect the foregoing by using two coats of zinc enriched paint.
- 31.19.33 Ensure that the entire conduit system is electrically continuous throughout, forming a fully bonded system, the whole system being effectively earthed. Carry out earth continuity tests before any conduits are concealed.

31.20 Metallic Conduit Installation – Concealed

- 31.20.1 Bury conduit in floor and/or roof screeds at least 25mm depth over its entire length. Plan and install routes so that the crossing of conduits is avoided. Ensure conduits laid parallel are at least 150mm apart. Fix conduits laid in "in-situ" concrete securely to the reinforcement steelwork. Fix conduit boxes to the shuttering.
- 31.20.2 Where concealed in plastered walls, ensure conduit shall have 50mm cover along its whole length and do not permit horizontal routes.
- 31.20.3 Fix by crampets or saddles, or other propriety fixing, at sufficient intervals to prevent displacement and in accordance with the relevant Standards.
- 31.20.4 Where conduits are laid fixed across constructional expansion joints, use expansion couplings with suitable earth bonding conductors proving equipotential bonding.
- 31.20.5 Where conduits are specified to be installed above suspended ceilings, fix to the building fabric at distances to comply with the relevant Standards, by saddles or suspended on steel strapping or on circular steel suspension sets using saddles or patent suspension clips. Do not use suspensions which allow the sideways movement of conduit.
- 31.20.6 Ensure all lighting points or cord switch points have fixings independent from the ceiling structure and similar to the conduit fixings above.
- 31.20.7 Where conduit is concealed above ceilings of plaster, or rigid construction, bring ceiling boxes flush to the finished ceiling level; use extension rings to ensure compliance with this clause.
- 31.20.8 With ceilings and walls of the demountable type, fit conduit boxes above the ceiling or flush in walls with an extension ring to close the gap to the ceiling face or wall finish.
- 31.20.9 Ensure all adaptable boxes, draw-in boxes, conduit boxes, etc., have overlapping covers flush with the finished walls or ceilings.



- 31.20.10 Where partitions and walls are of such a construction that it is not possible to make normal conduit entry to the flush accessory box, terminate the conduit in a box deep into the wall and use deep extension boxes so as to finish flush.
- 31.20.11 Where necessary, include break joint rings at all luminaire or ceiling switch points.
- 31.20.12 Where surface mounting equipment is mounted on a concealed conduit installation, drill, bush and mount the equipment over a recessed adaptable box so as to conceal the flush installation.

31.21 Metallic Conduit Installation – Surface

- 31.21.1 Ensure conduits are installed neatly on the surface and routes are truly horizontal, vertical, or parallel with the features of the building. Lay all double sets parallel.
- 31.21.2 Wherever possible, locate conduits in unimportant areas and pass through walls using back-entry type boxes.
- 31.21.3 Support conduits by spacer bar saddles fixed at regular intervals not exceeding that set out in the relevant Standards.
- 31.21.4 Where two or more conduits are installed parallel, increase and decrease bending radii to ensure a continuous parallel installation.
- 31.21.5 Do not use running couplers with locknuts for Class 4 work; use only manufactured conduit unions.
- 31.21.6 Where conduits are specified for installation in the ground use those of the Class 4 pattern and wrap in mastic damp-proof bond tape, half-lap and extend for at least 300mm beyond the ground emergence point.
- 31.21.7 Arrange conduits so as to minimise the collection of water from condensation or other sources. Where necessary drill drain holes (3mm diameter) at the lowest points or at any other points required by City University Operations Department.

31.22 Metallic Flexible Conduit

- 31.22.1 Ensure metallic flexible conduit complies with the relevant Standards and is of helical coiled steel with a waterproof sheath overall. Use such conduit generally for final connections to equipment in the following locations:-
- 31.22.2 All equipment subject to vibration, including all electric motors.
- 31.22.3 All equipment which is subject to adjustment or which can be withdrawn for maintenance.
- 31.22.4 Motorised valves, thermostats, controls, sensors, forming part of a piped or ductwork system, storage tanks; oil burners, etc.
- 31.22.5 Ensure metal flexible conduit is not less than 300mm, and generally not longer than 500mm, unless agreed with City University Operations Department.



- 31.22.6 Terminate flexible conduits in proprietary manufactured couplings forming a waterproof and damp-proof connection.
- 31.22.7 Terminate the rigid conduit with an appropriate box to receive the flexible conduit.
- 31.22.8 Cables within flexible conduit must be tri-rated type.

31.23 Non-Metallic Conduit and Fittings

Non-Metallic Conduit

- 31.23.1 Non-Metallic Conduit may only be used with the prior written agreement of the City University Operations Department.
- 31.23.2 Ensure conduits comply with the relevant Standards and be heavy gauge, high impact, self-fire-extinguishing PVC, free from imperfections, smooth inside and outside; of minimum diameter 20mm.
- 31.23.3 Ensure conduits are of the same colour throughout the entire installation.

Non-Metallic Conduit Fittings

- 31.23.4 Ensure all fittings are of the same specification and colour, and comply with the relevant Standards, and as follows:-
- 31.23.5 Ensure standard boxes are circular pattern with push fit spouts to the relevant Standards, with a PVC lid held in place with brass or nylon screws.
- 31.23.6 Provide circular boxes for all outlet points for luminaires and ceiling switches. Ensure boxes have fitted brass earth terminals and be heat resistant and reinforced with tapped metal inserts for fitting and fixing screws.
- 31.23.7 Ensure adaptable boxes are to the same specification as the conduit, PVC lids fixed by brass or nylon screws. Do not use adaptable boxes smaller than 75mm x 50mm or larger than 300mm x 300mm. Where cable joints are permitted or specified, ensure boxes are of adequate size to contain the terminal block and space for making neat connections.
- 31.23.8 Fix the terminal block to the adaptable box using brass or nylon screws.
- 31.23.9 For surface mounted PVC conduits fit saddles of the spacer bar type to provide 3mm clearance fix saddles with brass screws.

31.24 Non-Metallic Conduit – Installation

- 31.24.1 Non-metallic conduit is only to be used with the prior written permission of City University Operations Department. Ensure all non-metallic conduit work is carried out by tradesmen skilled in this work.
- 31.24.2 Ensure all non-metallic conduits are sized to comply with the relevant Standards.

- 31.24.3 Ensure all cutting is done using a proprietary cutting tool. Use of hacksaws and the like is not permitted.
- 31.24.4 Use PVC adhesive for jointing conduit to couplers, adaptable boxes etc. Use proprietary adhesive for the jointing; "fixed" type for rigid connection and "flexible" type for expansion joints. Insert square cut conduits to the full depth of the spout.
- 31.24.5 Where conduits terminate in trunking or accessories without a smooth bored spout, make the connections by female plain to threaded adaptors, secured by a male bush.
- 31.24.6 Where conduits terminate at tapped conduit entry boxes, use male plain to threaded adaptors.
- 31.24.7 Install separate protective conductors with green and yellow coloured insulation for all circuits and services. Design and install the rating of protective conductors is in accordance with the relevant Standards.
- 31.24.8 Make all bends, with the exception of solid normal bends, on site by using the appropriate bending springs. Make the radius of the bends not less than 2.5 times the diameter of the conduit. Make bends only at ambient temperatures of + 10°C and above. Do not use elbows or tees.
- 31.24.9 Take special care to prevent dirt and moisture entering conduit / installations. Use screwed caps or shaped plugs only.
- 31.24.10 Space expansion joints at a maximum of 6m with a joint made using flexible type adhesive at the spout and end of a coupler.
- 31.24.11 Use 2 No fixings with large washers for conduit boxes supporting luminaires or ceiling pull switches.
- 31.24.12 Install inspection boxes in accessible positions giving due regard to switch and socket position and any aesthetic requirements.
- 31.24.13 Do not use non-metallic conduits in situations where ambient temperatures are likely to be lower than -5°C or higher than 60°C. If temperatures are likely to be lower than -5°C, but not lower than -25°C then use type 'B' PVC conduit, as described in the relevant Standards.

31.25 Non-Metallic Conduits - Surface Installation

- 31.25.1 Ensure non-metallic conduit works, where surface mounted, comply with the same requirements for metallic conduit concealed installations.

31.26 Non-Metallic Flexible Conduit

- 31.26.1 Ensure non-metallic flexible conduits comply with the relevant Standards and with the requirements for metallic flexible conduits. Also use such conduits generally for final connections to equipment in the following locations:-
- 31.26.2 Thermostats, control sensors etc. not forming part of a piped or ductwork system. Do not use non-metallic flexible conduit for final connection to heat producing equipment.



- 31.26.3 Use non-metallic flexible conduits of the heavy duty reinforced pattern, of the same manufacturer, colour and composition as the remainder of the PVC conduit installation.
- 31.26.4 Terminate non-metallic flexible conduits with the coupling connection produced by, or recommended by, the manufacturer.
- 31.26.5 Use only weatherproof flexible conduit in external or continually damp locations.

31.27 Conduits and Fittings – Flameproof Areas

- 31.27.1 Conduit installations, in an area designated as a flameproof area, that is classification zones 0, 1 and 2, need not in itself be a flameproof installation provided that approved stopper glands are used, on entry to all FLP equipment. A FLP housing is required in all cases where electrical apparatus is used, including terminal connections, except for intrinsically safe circuits. Refer to the relevant Standards for conduit systems for intrinsically safe (IS) circuits.
- 31.27.2 Provide seam welded, heavy gauge conduits, Class B, hot dip galvanised.
- 31.27.3 Ensure all connections are screwed, with minimum entry of five threads, cut to exact length with no spare thread visible. Provide connections to accessories using a graphite based grease.
- 31.27.4 Install sealing glands where conduit installation is intended to be gas tight. Take care to properly install, support and plan the installation to minimise the effect of, spillage of hazardous materials. Ensure installation conforms fully with the requirements of the particular project requirements.

Fittings

- 31.27.5 Ensure flameproof boxes and housings conform to classification EExd IIb T4, or better. Variations from this standard will only be made, if agreed in writing with City University Operations Department. All conduit entries to FLP boxes will be via a sealing gland, Hawke type BCSB 656 range, or equal. A Walsall union type F1820/G/MC range will be fitted in the conduit run, not closer than 400mm to the FLP box to facilitate ease of installations and future alterations. Pull boxes will be either, Walsall weatherproof through boxes type F522 or three way type F523, or equal. Lids will be sealed metal to metal using graphite grease, except for external installations, which are required to be weatherproof also. For these installations a pull box or terminal box will be fitted with a neoprene gasket, as supplied by the manufacturer. Ensure all openings not used will be fitted with approved stopper plugs.
- 31.27.6 Where the final connection is for an electric motor, or item of plant subject to vibration or adjustment, the conduit will be connected to a FLP terminal box, within a minimum distance of 500mm or as close as is practical. The final connection will be either:-
- a) Kopex, or equally FLP flexible conduit, using either the FL H04 or FL H05, range of sealing glands, or
 - b) Delta, or equivalent, rubber insulated and sheathed, screened and PCP no HOFr, sheathed cords of the ref. 380 range with associated sealing glands, Hawke, or equal 501/453 series.
- 31.27.7 Determine and agree all manufacturers equipment types, references and catalogue numbers with City University Operations Department.



31.28 Existing FLP installations

- 31.28.1 Maintain existing installations using boxes etc., certified to the original standards. Ensure new works or additions comply to the new standards.
- 31.28.2 Conduits and fittings - flameproof areas - to contain intrinsically safe (IS) circuits.
- 31.28.3 Conduits will be generally as detailed in the Specification. Ensure the installation, when completed, is gas tight, to prevent degradation of the circuit.
- 31.28.4 Fittings such as pull boxes, terminal boxes etc. will be Walsall F450 series or equal and will be gasketed, to provide an adequate seal.
- 31.28.5 Fit complete installations with small labels, at frequent intervals, stating 'IS Circuit'.
- 31.28.6 Ensure conduits and fittings for IS circuits are separate from any other circuits, throughout their entire length.

32 EARTHING AND BONDING

32.1 General

- 32.1.1 Design and install the whole of the earthing and bonding installations in accordance with the requirements of the relevant Standards and City University Operations Department requirements.
- 32.1.2 Ensure all enclosures, equipment, exposed conductive parts, extraneous conductive parts, structural steelwork, metallic ceiling grids, metallic trunking, metallic conduits, metallic cable trays, pipes, ducts, baskets and any other metalwork, other than any live part, forming protection or part of the electrical installation, including apparatus and appliances, are effectively bonded to earth and do not form part of the earth fault path of the protective conductor system.
- 32.1.3 Ensure all LV socket outlets switches, fuse connection units and accessories etc., have a flexible BS 6231 green/yellow PVC insulated 2.5 sq. mm stranded copper conductor as a 'fly lead' connected between earth terminals secured to both accessory assembly and box.
- 32.1.4 Provide fly leads as described above for all hinged panels of switches, switchgear, control cubicles, distribution boards, etc., Route/protect the 'fly leads'to obviate damage to the cables when panels are opened and closed.
- 32.1.5 Ensure all main water pipes, main gas pipes other service pipes and ventilation ducting (including ductwork flexible connections, riser of central heating and air conditioning systems) oil pipe services, storage tank, piped gas systems, etc., and the exposed metallic parts of the building structure are effectively connected to the main earthing terminal points using, where applicable, earthing clamps which conform to the relevant Standards.
- 32.1.6 Ensure the installation has all incoming services bonded to earth at the point of entry. For the purposes of this clause a building is defined as a separate structure. Structures linked by a corridor, subway or bridge are considered to be separate structures.
- 32.1.7 Bond together services entering/leaving plant rooms, boiler houses, calorifier rooms, bathrooms, kitchens and other wet-process areas, and bond to the electrical installation protective conductor system.
- 32.1.8 Extraneous metalwork to be bonded includes:-
- a) Metal ceiling grids by bonding each primary grid member using a 4mm sq. LSOH insulated copper conductor.
 - b) Metallic balustrades and handrails.
 - c) Metallic ladders and companion ways.
 - d) Suspended metal floor systems including supports/frames. Minimum two bonds per room plus one additional bond per fifty square metres.
 - e) All other exposed metallic parts and equipment permanently secured to or forming part of the building structure including exposed metalwork of hollow partitions and separate sections of duct / pipework insulation metallic covering.

- 32.1.9 Ensure that all exposed or extraneous conductive parts, having a resistance to earth of less than one megohm are bonded to the electrical services earth.
- 32.1.10 Prove each circuit protective conductor prior to making any supplementary bonding connection.
- 32.1.11 Fix copper tape to the building structure by means of purpose-made 'spacer bar' saddles.

32.2 Site Supplies Received At Low Voltage

- 32.2.1 Earth is normally the earth terminals or earthed cable sheath of the incoming supply installation, using a TN-S system of earthing.
- 32.2.2 Where the site supply requires additional connection to earth, install an earth electrode system to meet the site and soil conditions all as described for Lightning Protection Systems. Provide solid drawn high conductivity copper rods, 16mm diameter and 1200mm sections with internal screw and socket joints.
- 32.2.3 Fit sections with hardened steel tips and driving caps. Ensure depth of the driven rods are a minimum of 2400mm and the spacing is at least equal to their length.
- 32.2.4 Ensure no electrode is within 3000mm of the building foundations.
- 32.2.5 Make connections by using proprietary clamps and provide with a concrete inspection pit with removable covers inscribed "EARTH".
- 32.2.6 Provide earthing terminals at all main incoming site supply positions and connect to Earth. Ensure main and/or sub-main panels have an earthing terminal and are effectively connected to Earth.

32.3 Sub-Station Earthing / Connections to Switchgear

- 32.3.1 Ensure the minimum earthing requirements for site sub-station earthing and associated connections to switchgear etc. conform with the relevant Standards and as detailed in the Specification and on the Particular Project drawings.
- 32.3.2 Ensure the position of the L.V. neutral to earth link in the main LV switchpanel affords correct operation of the specified earth fault protection where applicable.
- 32.3.3 Bond sheath and/or armour at one end only where single core, lead covered, aluminium or steel wire armoured cable's are installed. Mount glands on insulated gland plate at the unbonded end. Bond secondary connection of transformers/generators at the switchboard end.
- 32.3.4 Install an external earth electrode system to meet the site and soil condition. Use solid drawn high conductivity copper rods of proprietary manufacture, 16mm diameter 2400mm long sections with internal screw and socket joints. Determine quantity of copper rods at time of design. Take account of special design requirements to suit soil type, location, ground conditions and quantity/selection of electrodes. Locate earth electrode system close to main earth busbar of substation position.
- 32.3.5 Fit rod sections with hardened steel tips and driving caps. Ensure the depth of driver rod is a minimum of 2400mm and the spacing between rods is at least equal to the driven length. Ensure no electrode is within 3000mm of the building foundations, and is driven into the ground vertically and below finished ground level.

- 32.3.6 Interconnect earth rods using minimum 25mm x 3mm copper tape, buried 500mm below finished ground level, and using purpose made clamps.
- 32.3.7 Divide the earth rod system into two equal parts so that testing can be carried out on each half without loss of earthing facilities.
- 32.3.8 Ensure that each part of the system achieves a resistance less than 1 ohm measured in accordance with the relevant Standards.
- 32.3.9 Connect each part of the system to proprietary testing links using insulated conductors, terminating at the sub station earth bar.
- 32.3.10 Install two earthing conductors from the electrode systems to the main earth bar test links. Each earthing conductor shall be a minimum of 25mm x 3mm green/yellow covered copper tape or 70 sq. mm green/yellow LS0H covered copper cable. Connect earthing conductors to the earth rods by a purpose made bolted clamp.
- 32.3.11 Connect earthing conductors to the earth bar test link by a tinned 'sweated' and bolted connection. The earthing conductors shall be buried 500mm below ground level and shall enter the building by a duct. Within the building fix to surfaces by purpose made clips or cleats.
- 32.3.12 Ensure connections to the earth electrodes are readily accessible for periodic inspection, and protected against mechanical damage and corrosion. Make the connection to the rod by means of a purpose made clamp and lay below ground level in a concrete inspection pit having a removable cover prominently inscribed "Earth".
- 32.3.13 Provide earthing terminals at all main incoming supply positions and connect to Earth. Ensure main and/or sub-main panels have an earthing terminal and are effectively connected to earth. Use the main LV switchpanel earth busbar for connection of outgoing cable armouring and sheaths to earth.

32.4 Circuit Protective Conductors

- 32.4.1 Provide Circuit Protective Conductors for protection against earth leakage and earth fault currents in accordance with the relevant Standards.
- 32.4.2 Ensure Circuit Protective Conductors are provided by one or more of the following methods:-
 - a) Separate Copper Circuit Protective Conductors with yellow/green insulation.
 - b) Armouring and/or metal sheaths of armoured cable.
 - c) An integral protective conductor of any multi-core cable.
- 32.4.3 Size of protective conductors to be in accordance with the relevant Standards and as indicated in the Specification or on the drawings. Minimum conductor size 1.5mm² copper.
- 32.4.4 Terminate all circuit protective conductors, when fixed to bolted connections, using compression type lugs made with an automatic purpose made machine.
- 32.4.5 Bond the metal sheaths and/or armouring of paper and LS0H insulated cables at both ends to the metal parts of the equipment to which they are connected, utilising a proprietary brass earthing tag and brass

nut and bolt. Install copper circuit protective conductors between brass nut and bolt to equipment internal main earth terminal.

- 32.4.6 Take appropriate measures to prevent corrosion of connections to copper conductors where aluminium cable armour and glands are used.
- 32.4.7 When flexible conduit is used, ensure the protective conductor at the equipment end is made-off to the equipment earth terminal. Install the protective conductor within the conduit and suitably sized for the circuit(s) passing through.
- 32.4.8 Where main and sub-main circuit protective conductors are provided install a common copper tape with T joints. The tape shall be green/yellow LS0H covered and of size specified. Joints shall be riveted and sweated. Wrap exposed metal with adhesive green/yellow LS0H tape. Fixings shall be purpose made clips.
- 32.4.9 Install separate circuit protective conductors, where run through conduits and trunking, for each lighting and small power final circuits each circuit. Ensure each distribution board has an earth terminal busbar with a separate terminal for each circuit protective conductor.

32.5 Extensions and Alterations to Existing Installations

- 32.5.1 Check existing installations which are being extended to ensure that the existing earth continuity conductors and earthing leads comply with the relevant Standards.
- 32.5.2 Where a connection is made to another earth continuity conductor or earthing lead, supply and fix a permanent label indelibly marked with the words "SAFETY ELECTRICAL EARTH - DO NOT REMOVE".

33 LIGHTNING PROTECTION

33.1 General

- 33.1.1 Carry out complete installation of the lightning protection system described in the Specification and as indicated on the particular project drawings and details.
- 33.1.2 Provide a lightning protection system(s) consisting of air terminations (including roof conductors), down conductors, joints, bonds (including bonding to exposed permanent metal parts of the building and bonding to any metal parts of the structure). Test joints, earth terminations and earth electrodes, shall form the lightning protection installation detailed in the Specification and on the drawings.
- 33.1.3 The Installer shall be fully responsible for the supply and installation of the total Lightning Protection system.
- 33.1.4 Ensure that all metal work forming part of the structure and that all metal work attached to the outer surface (e.g. roof cladding) or which projects through the wall or roof is electrically continuous. Where this is not so, bonding shall be carried out in accordance with the relevant Standards.
- 33.1.5 N.B. Care shall be taken if any of the structural steelwork is intended to be used as part of the air termination/down conductor network. This may only be done in strict accordance with the relevant Standards, and carried out in accordance with the layout and details on the drawings.

33.2 Materials and Fixings

- 33.2.1 Provide air terminations (including roof conductors) and down conductors of copper, copper alloy or aluminium, except that aluminium shall not be used below ground level.
- 33.2.2 Provide steel cored copper rods earth electrodes.
- 33.2.3 Ensure all joints, bonds, terminations, nuts, bolts, washers, screws, rivet fixings etc., shall be made of materials as recommended in the relevant Standards. In all circumstances, any nuts, bolts, washers and screws shall be of stainless steel, unless otherwise indicated.
- 33.2.4 Give particular consideration to the risk of corrosion as detailed in the relevant Standards.
- 33.2.5 Install all conductors kink free, true and machined straightened. Ensure all conductors are LS0H sheathed in accordance with the colours detailed for each particular project. Agree all LS0H sheath colours with City University Operations Department prior to ordering or commencing works.
- 33.2.6 Ensure the type of building fabric is fully examined and inspected, and due allowance made prior to fixing conductors, brackets, saddles, clips on test points etc.
- 33.2.7 Ensure any bare steelwork bonds or joints associated with the lightning protection system is wire brushed where necessary and painted with two coats of zinc rich paint primer, followed by two coats of gloss black enamel. All painting requirements and procedures shall be agreed with City University Operations Department prior to commencing works on site.



- 33.2.8 Provide all fixings in accordance with Table 21-1 below. Approval of the type of clips, saddles and holdfasts to be used shall be obtained from City University Operations Department prior to commencing work.
- 33.2.9 Use clips either of metal as above, or of outdoor grade polycarbonate or polypropylene with snap on lids, which cannot be inadvertently removed. Ensure clips and saddles have rounded edges and countersunk screws. Brass components shall not be used.
- 33.2.10 Ensure no shot firing is used, and no drilling or welding of structural steelwork is undertaken without approval of City University Operations Department.

33.3 Air Terminations (Including Roof Conductors)

- 33.3.1 The use of pointed air terminations or vertical finials is not regarded as essential, except where dictated by particular project requirements or practical considerations. Use strike plates where suitable and agreed for each project.
- 33.3.2 Any vertical finials used to be 300mm high except where indicated on the particular project drawings.
- 33.3.3 Provide roof conductors of solid drawn rod of minimum dimensions 8.0mm dia or solid drawn strip of minimum dimensions 25 mm x 3 mm. Fix conductors with saddles or clips at intervals as recommended in the relevant Standards, and in all cases, fixed at maximum centres of 500mm.
- 33.3.4 Determine type of roof conductor required for each particular project, and agree with City University Operations Department. Provide sufficient clearance around conductors to allow for movement due to expansion and contraction.
- 33.3.5 Ensure where indicated, metal framed or metal clad roofs or metal copings which form part or all of an air termination are bonded across joints between constituent parts. Do not drill roofing or coping without approval of City University Operations Department.
- 33.3.6 Fix roof conductors along the ridges and roof perimeter and follow all building features and surfaces. Interconnect roof conductors with all other conductors run across the roof, so that no part of the roof is more than 5 metres from the nearest horizontal conductor in accordance with the relevant Standards. Incorporate the recommendations of the relevant Standards for sloping roofs, and roof conductors installed in accordance with the details and layout on the particular project drawings.

33.4 Down Conductors

- 33.4.1 Provide for conductors connecting between a test clamp on the outside of a building and an earth electrode, to be sheathed; conductors interconnecting copper electrodes may be left bare. Provide conductors in other locations to be sheathed where indicated. Use sheaths of LSOH, extruded, shrunk-on or similarly applied. The sheath colour shall be agreed with City University Operations Department for each particular project.
- 33.4.2 Do not fix down conductors where the profile of the building would cause an overhang, or re-entrant loops to be formed.

- 33.4.3 Where the reinforcement of a concrete structure forms the down conductors, carry out welding of the reinforcement in conjunction with the Builder. Carry out testing for electrical continuity to all welding and reinforcement connections.
- 33.4.4 Carry out bonding connections to the steel, where the steel reinforcing or the steel frame of a building forms the down conductors of the lightning protection system.
- 33.4.5 Determine the length of tail to be left, and carry out all subsequent connections associated with the Lightning Protection System.

33.5 Joints

- 33.5.1 Ensure the Lightning Protection system has as few joints as possible. Ensure joints are mechanically and electrically effective, and adequately protected from corrosion and erosion. Carry out all joints using an oxide inhibiting compound. Ensure all joints between air terminations, air terminations/down conductors, bonding, down conductors/earth electrodes etc., are in accordance with the relevant Standards.
- 33.5.2 Protect joints and connections by a coating which will form a seal and exclude moisture in all weather conditions. At connections to earth electrodes the coating shall cover all exposed conductors. Ensure protective coatings are of a waterproof, inert, tenacious material and of one of the following forms:
- a) Solvent cutback thixotropic corrosion preventative, forming a film of resilient matt petroleum wax;
 - b) A fast drying durable rubberised sprayed coating;
 - c) A heat-shrink clear sheathing.
- 33.5.3 Thoroughly clean and coat all contact surfaces with an anti-corrosive electrical jointing compound suitable for the conductor material. For bi-metallic joints use separate abrasive to clean each metal.
- 33.5.4 Carry out joints between conductors of the same metal, other than at test points, by the use of proprietary clamps, the Thermit welding process or by riveting and sweating. Ensure overlaps of conductors are not less than 100 mm.
- 33.5.5 Do not make bi-metal joints at test points nor between the test point and earth electrode.
- 33.5.6 Ensure bonding connections to other metal parts of the building are electrolytically compatible with those metal parts.

33.6 Bonds

- 33.6.1 Ensure all bonding is to be mechanically and electrically effective, and adequately protected from corrosion and erosion.
- 33.6.2 Bond all exposed permanent metal parts of the building to the Lightning Protection system. Ensure all metallic projections such as radio and television aerial masts, chimneys, ducts, vent pipes and railings, on or above the main surface of the roof are bonded to the air termination network. Ensure metal entering or leaving the structure in the form of sheathing, armouring or piping for electric, gas, water, rain, steam,

compressed air or any other service is bonded as directly as possible to the earth termination. Carry out near to the point at which the service enters or leaves the structure where applicable.

33.7 Test Joints

33.7.1 Provide at each down conductor a test joint/clamp. Installed in a position convenient for tests, but not in a position inviting unauthorised interference.

33.8 Earth Electrodes

33.8.1 Determine the type and number of earth electrodes for each project.

33.8.2 Unless otherwise indicated, ensure earth rods are 16 mm nominal diameter extensible copper-clad high - tensile steel rods connected together. Copper cladding to be molecularly bonded to the steel and to be not less than 0.25 mm thick. Ensure driving heads are of high - tensile steel. Rods to be connected by screwed joints by one of the following methods:

- a) Provide rods with threads roll - formed with a minimum thickness of 0.05 mm copper in the roots of the thread; couplers to be of high strength silicon - aluminium bronze alloy and threads counter bored at the ends so that couplers completely enclose the threads on the rods.
- b) Ensure the ends of the rods are internally threaded; couplers to comprise a copper ferrule with the phosphor - bronze coupler screw; apply a corrosion inhibiting paste to the threads on rods and couplers.

33.8.3 Connect each down conductor to an earth electrode or electrodes.

33.8.4 Allow for trials and tests to be carried out, in accordance with the relevant Standards before proceeding with the installation, in order to ascertain the form, quantity and length of electrodes most suited to the physical nature of the surrounding soil.

33.8.5 Ensure the minimum length of each earth electrode is 2400mm and comprises 16 mm dia rods, complete with driving studs and spikes.

33.8.6 Install electrodes in undisturbed ground. Ensure the distance between any two electrodes is not less than 1.25 times the depth of the longer electrode.

33.8.7 Carry out excavations and backfilling. Backfill, immediately surrounding electrodes, to have a low specific resistivity and good water retention properties. Ensure backfilling is well compacted and watered.

33.8.8 Provide electrode seals where earth rods are to be installed through the base slab of a building. Ensure the rods are driven and seals fitted before concrete is poured or the seals incorporated in the slab and the rods driven at a later date. Avoid harmful ingress of water when driving the rods.

33.8.9 Base the lightning protection installation upon known soil and ground conditions of the site. Established soil/site conditions at the time of the initial site visit prior to design or installation proceeding. Include soil resistivity tests to be carried out and provide reports.



- 33.8.10 Ensure earth electrode construction is in accordance with the relevant Standards. Site connection between the down conductor and earth electrode as close as practicable to the structure and down conductor, and in close proximity to any positions indicated on drawings. Ensure connections are easily accessible i.e. inspection pits or chambers provided if the connection is below ground.
- 33.8.11 Provide inspection pits with removable top cover flush with finished ground level, unless agreed with City University Operations Department to be below top soil level. Enclosure to be a purpose made concrete inspection pit, a galvanised steel inspection pit embedded in concrete, or similar agreed with City University Operations Department. Ensure earth electrode connection is just below the lid of the inspection pit with adequate access for testing purposes. Check buried down conductors leading to earth electrode terminations are at least 600 mm deep. Agree with City University Operations Department final positions on site. Connections to earth electrodes shall be by bronze, gunmetal or copper clamps with phosphor - bronze bolts. Edges of clamps shall be rounded. Provide all connections wrapped in "Denso" tape or equivalent as indicated in the Specification.

33.9 Testing / Commissioning

- 33.9.1 Carry out intermediate tests at relevant stages throughout the system installation. Carry out, upon completion of the system, a full test on the lightning protection installation.
- 33.9.2 Ensure all tests are to be in accordance with the relevant Standards.
- 33.9.3 For intermediate tests include:-
- a) Test to ascertain the resistance of the whole of the earth termination network without taking account of any bonding to other services. The total network resistance shall not exceed 10 Ohms.
 - b) Test to ascertain the resistance of each earth electrode. Each of these earths should have a resistance (in Ohms) not exceeding the product given by 10 times the number of earth electrodes to be provided.
- 33.9.4 Ensure final test includes:-
- a) Test to ascertain the resistance value of the whole lightning protection system. This shall not exceed 10 Ohms.
- 33.9.5 Carry out any modification required to the electrode system in order to obtain a value of 10 Ohms or less.
- 33.9.6 Provide for all intermediate tests and final tests to be witnessed, and results submitted for approval by City University Operations Department.
- 33.9.7 Carry out the final tests in the presence of City University Operations Department. Detail the results of all tests on appropriate witness Test Certificates. Verify that the Lightning Protection system complies with the relevant Standards and other relevant regulations and codes etc.
- 33.9.8 Ensure all test certificates, include details of all test procedures used, and types of test instruments.
- 33.9.9 Supply, upon completion of the installation, all installation drawings and records/information as detailed in the relevant Standards, and as indicated in the Specification, including all schedules and equipment details etc.

35 SURGE PROTECTION DEVICES

33.10 General

- 33.10.1 Each distribution board supplying lighting or general power shall be supplied with surge protection devices for protection of electronic equipment against induced surges and transient over voltages on computer networks, instrument systems, telephones and power lines etc. Unless agreed in writing by City University Operations Department these shall be Schneider or Furuse type.
- 33.10.2 Ensure surge protection devices protect electrical and electronic equipment and devices against indirect effects of lightning strikes and electrical faults.
- 33.10.3 Provide surge protection devices in locations in circuits to protect vulnerable equipment and components without affecting normal operation. Ensure surge protection devices divert surge currents and safely 'clamp' transient over voltages. Provide devices which automatically reset, without damage, following any surge or transient etc. occurring.
- 33.10.4 Agree with City University Operations Department requirements for provision of surge protection devices, for each particular project and equipment to be used.
- 33.10.5 Ensure application of surge protection devices provides full system protection to all sections of circuits.
- 33.10.6 Provide surge protection devices at both ends of each protected circuit(s) when systems are interconnected or field equipment is considered to be at risk.
- 33.10.7 Ensure low resistance and low impedance earth connectors are provided to all surge protection devices, in accordance with manufacturers recommendations and requirements. Provide all earth cables and connections as short and direct as possible. Ensure all earthing arrangements are fixed and protected in accordance with the specification.
- 33.10.8 Ensure all devices have BASEEFA certification. Provide for special considerations in hazardous area equipment and applications where surge protection is required.



34 HAZARDOUS AREAS

34.1 CLASSIFICATION

34.1.1 The British Standard 'BS5345 Code of practice for selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres' parts 1 and 2 form the basis of City University Operations Department's requirements.

34.1.2 Other Standards used in area classification include

- a) IEC 79 Part 10 Classification of hazardous areas
- b) IP Model Code of Safe Practice Part 15

34.2 Area Classification

34.2.1 The designer and or the contractor is responsible for producing drawings depicting the initial extent of any zone 1 or zone 2 hazardous areas. The drawings must incorporate notes sufficiently detailed to explain the extent of the zones and justification of any assumptions made. The actual zone boundaries must be established and agreed between the designer and the City University Operations Department and if applicable the users of the plant. Boundaries that may be affected if additional hazardous materials are kept in the area must be indicated. City University Operations Department can advise on requirements and the organisation for the classification exercise. Copies of calculations made including those to establish extents of release and evaporation rates must accompany the drawings or be included in the drawing notes. City University Operations Department will use and may update the original information during area classification reviews, maintenance operations or change of use of the area.

34.2.2 For ease of retrieval it is intended that wherever possible the annotated drawing(s) becomes the single point of information reference.

34.3 Area Classification Team

34.3.1 It is not practical for any one person to carry out an area classification exercise. The results of the exercise are primarily of interest to the Operations Department, and as such the work often falls on these disciplines to progress area classifications. The approach which appears to work for City University Operations Department is a team consisting of the Operations Department, Safety Department and a senior representative of the area under consideration. Others may be co-opted as necessary. The team will consider all sources of release under normal and fault conditions but not catastrophic failures.

34.4 Equipment Classification

BS 5501 Part 5 EN 50 018

34.4.1 The minimum classification for flameproof electrical equipment to be used in hazardous areas is EEx d IIB T4. The actual equipment classification must always be established from the hazardous area zoning drawing.



BS 5501 Part 7 EN 50 020

- 34.4.2 Control and instrumentation circuits may use intrinsically safe apparatus classified EEx i(a or b)
- 34.4.3 Copies of original certificates must be supplied for all hazardous area equipment. Cable calculations demonstrating conformity to Intrinsically Safe criteria must be supplied. All documentation must be forwarded to the City University Operations Department.
- 34.4.4 It is essential that any device used to achieve protection is accessible for compliance checks and future maintenance. This includes any software and licences.

35 INSTALLATION

35.1 Cables and Wiring

35.1.1 Cables and wiring in hazardous areas need to provide a level of protection suitable for the zone of use.

35.2 Zone 1

35.2.1 The cables must be mechanically protected to provide a reasonable level of assurance that normal cable damage will not cause a source of ignition. Suitable protection includes;

- a) Cables within conduit systems
- b) Armoured cable
- c) Mineral insulated metal sheath cable

35.3 Zone 2

35.3.1 As for zone 1, except unarmoured cable may be used where risk of damage can be shown to be minimal.

35.3.2 Blue cable sheaths are used exclusively for I.S. circuits on the City University Operations Department site.

35.4 Conduit Systems

35.4.1 Stopper glands or boxes must be used at each entry point to any apparatus including terminal boxes. Corrosive environments may make the use of conduit systems undesirable.

35.4.2 An earth terminal, if used inside a through box, is considered to be a source of ignition, stopper glands will therefore be required.

35.5 Cable Glands

35.5.1 Cable glands should be fully tightened with no sealing washer in EEx (d) apparatus. A sealing washer should be used for maintaining an IP54 seal on increased safety, EEx (e) apparatus.

35.5.2 In addition to British Standard requirements, the minimum level of protection for EEx(e) and I.S. apparatus is IP 54

35.5.3 City University Operations Department recommend using glands from the Hawke Ex range. To facilitate maintenance the Hawke universal Ex gland is preferred. Glands on flame proof enclosures with a volume of more than 2 Litres must be compound filled.

Transition from Hazardous to Safe Areas

35.5.4 An appropriate gas tight barrier must be formed in the wiring system whenever a transition is made between a safe area to a hazardous area. Puddle flanges for multiple runs or an equivalent for single



circuits are suitable for conduit systems. Transit frames or agreed equivalent are suitable for armoured cables.

35.5.5 Fire barriers must be installed where circuits pass from one hazardous area to another.



36 EQUIPMENT

36.1 Motors

- 36.1.1 Unless otherwise indicated motors with a full load current in excess of 80A should be fitted with thermistors.
- 36.1.2 Plastic motor cooling fans, cowls and drive belts must be of anti-static materials.
- 36.1.3 Mechanical parts associated with the motor must be non-sparking.

36.2 Lighting

- 36.2.1 Luminaires in hazardous areas must be maintainable without breaking a gas or fire seal between different zones.

36.3 Socket Outlets

- 36.3.1 City University Operations Department have adopted 'ABB' flameproof socket outlets as a site standard for compatibility.

36.4 Materials

- 36.4.1 Only non-incindive materials may be used. Aluminium alloys should contain less than 6% magnesium by weight.



37 INSPECTION AND MAINTENANCE

37.1 General

- 37.1.1 BS 5345 part 1 Before an installation is accepted for use it will be examined to ensure the following criteria have been met. The list is not exhaustive and specialist apparatus may require alternative testing. The inspection is to ensure protection from ignition by electrical apparatus not for operational performance.
- 37.1.2 Drawings indicating the extent of the hazardous areas and copies of equipment certificates must be available to the City University Operations Department Electrical Inspector before the installation can be examined and hence approved.

37.2 Initial Inspection

- 37.2.1 Suitable signs at all entry points to the classified areas;
- 37.2.2 Zone Classification
- 37.2.3 Other precautions e.g.
 - a) No Solvent Storage in marked areas

37.3 Suitability of apparatus for area

- 37.3.1 Temperature Class
- 37.3.2 Gas Group
- 37.3.3 Zone
- 37.3.4 Certification
- 37.3.5 Rating

37.4 Effects of installation on apparatus

- 37.4.1 Cable used suitable for gland
- 37.4.2 Cable entries correct and assembled properly
- 37.4.3 Unused entry holes blanked correctly
- 37.4.4 Electrical connections tight
- 37.4.5 Mounting holes/arrangement not invalidating certificate



- 37.4.6 Apparatus securely fixed
- 37.4.7 Gaskets, if required, of correct type and correctly positioned
- 37.4.8 Correct use of sealing compound
- 37.4.9 No unauthorised modification to apparatus
- 37.4.10 No unauthorised gaskets
- 37.4.11 No incorrect lid or cover fixing bolts
- 37.4.12 No obstructions on flame paths;
- 37.4.13 No Hard setting compound in flame path
- 37.4.14 No Paint / tape in flame path
- 37.4.15 External earth stud connected to structure earth

37.5 Cabling

- 37.5.1 Continuity of earth bonding
- 37.5.2 No damage to cable sheath
- 37.5.3 Minimum bending radius not exceeded
- 37.5.4 Cables routed to avoid damage
- 37.5.5 Cables secured correctly
- 37.5.6 Stopper box or agreed sealing between safe and hazardous areas

37.6 Labelling

- 37.6.1 Cables identified
- 37.6.2 Apparatus tagged
- 37.6.3 Apparatus record completed and correct.

37.7 Electrical Tests

- 37.7.1 Insulation resistance of apparatus
- 37.7.2 Earth loop impedence

40 STATIC ELECTRICITY

37.8 General

- 37.8.1 All levels of static electricity generated in flameproof areas are considered undesirable and all reasonable practical means should be taken to eliminate them.
- 37.8.2 This section of the standard is based on the requirements and recommendations of BS 5958 Parts 1 and 2 1991 - Code of Practice for control of undesirable static electricity. The section is not intended to be a definitive guide to static electricity. Flow rates of insulating liquids, plant design and operation also contribute to the control of electrostatic risks.

37.9 Building Finishes

37.10 Non-conductive wall finishes.

- 37.10.1 These may be used in areas regularly washed or sponged down with water. They must not be used in de-humidified areas or areas with controlled dry environments where the humidity is generally controlled 50%Rh or below.
- 37.10.2 Special attention should be given to dusty areas to prevent free air borne dust clinging to wall finishes. Plastic materials must have additives to reduce their maximum resistance, measured from the longest path to earth of 100 MOhms or less.

37.11 Floor finishes

- 37.11.1 The finished floor must have a total resistance of 100 MOhms or less, measured via the longest path. Floor composition will include a stainless steel wire grid, connected by crimped joint at each cross over point, laid directly on the floor seal or membrane before tiles or other floor finish is laid. The diagonally opposite ends of this grid will be connected to stainless steel earth wires, not less than 12 gauge, and terminated in 100mm by 100mm boxes, using standard connections. These boxes will be accessible for test purposes. From the boxed terminations, connection will be made to the main earth system, using standard copper earth wire. The grout laid on the floor grid must be semi-conductive.

37.12 Floor Plates

- 37.12.1 In locations where process materials are, loaded, unloaded, transferred etc., by hand, a stainless steel, or other product resistant, metal plate, of adequate size and location, to ensure the operator must be standing on it to perform his duties, must be flushed into the floor. This plate must be connected electrically to the floor grid.

37.13 Plant Metalwork

- 37.13.1 All conductive material such as metal frames, pipes, structures, floor plates etc., must be connected to earth in such a manner so that the continuity to earth measured from any point to earth, does not exceed 10 Ohms.

37.14 Isolated Conductors

37.14.1 Sparks from isolated conductors are considered to be the most incendive type of discharge. It is essential that all such conductors are earthed. Examples include:-

- a) Metal flanges on glass or plastic pipes
- b) Metal spiral reinforcing in hoses
- c) Metal components of valves constructed of insulating materials (eg handles)

37.15 Pipes

37.15.1 Non-conductive pipes and materials are defined as all materials having a surface resistance to earth greater than 1 MOhm, measured at the farthest point from earth.

37.16 Metal Pipes

37.16.1 Metal pipelines are usually adequately bonded via their flanges and bolts. Star washers are a convenient way of ensuring bonding across bolted flanges. If a section of pipeline can be isolated from earth during normal operation it should be earthed independently.

37.17 Metal conductive pipes with inner nonconductive sleeves

37.17.1 Starting at one end and finishing at the other end, at intervals not exceeding 2 metres in length, a suitable metallic washer will be inserted between two flanges, the pipes on either side of such flanges will be connected by an easily removable tinned copper strap which is also connected to the metal washer. Star washers are an acceptable alternative to a tinned copper strap. Each "run" of pipework will then be connected to the main static earth system, in such a manner to ensure that disconnection of one pipe 'run' will not affect the earth continuity of other pipe 'runs'. The maximum resistance to earth measured from any point must not exceed 10 Ohms.

37.18 Non-conductive pipes

37.18.1 To safely discharge internal static electricity, the pipes will be treated as lined pipes, except that the metallic washers will be connected together by a tinned copper tape fixed to the pipe with stainless steel tie wraps. The method of connection to each washer will be so arranged, that disconnection of any washer will not break the continuity to earth of remaining washers, in any one line.

37.18.2 The pipe should be installed such that the possibility of static charging by rubbing or steam impingement is avoided.

37.19 Earthing points for Portable equipment



37.19.1 At each and every location, for charging and discharging all process product and materials, utilising portable equipment, including small drums and pipe transfer stations, a 25 x 6mm copper bar must be suitably located, connected to the earth system, for attaching jump leads, with crocodile clips, to the portable equipment.

37.20 Identification

37.20.1 The static earth system will be identified by permanent labels at strategic points, these will include all major termination points, earth points for portable equipment and junction boxes. Labels will read "STATIC EARTH POINT". Labels will be Traffolyte or similar, black letters on a white background.

37.21 Testing and Certification

37.21.1 Each pipe run, trunking, structure etc., will be tested after completion.

37.21.2 All walls and floors will be tested in identifiable areas (i.e. each room or production floor).

37.21.3 A test certificate will be issued recording details of date, location, specific item, or area, and test results and must be signed by the person carrying out the test and the company he represents.



LIGHTING

38 GENERAL LIGHTING

38.1 Luminaire Standards

- 38.1.1 Use luminaires of an approved type and manufacture, and be manufactured in accordance with the appropriate Design and Installation Standards and Requirements.
- 38.1.2 Installed lighting load in general office areas shall be less than 11W/m². See also 38.1.6
- 38.1.3 All internal and external lamps must meet or exceed the Energy Technology List (ETL) criteria. The use of incandescent, tungsten, tungsten halogen or fluorescent lamps is not permitted. LED lighting only shall be used. The installer / manufacturer shall warrant the equipment, control gear, drivers, luminaire for 5 years or 50,000 hours from the formal completion of the works. All luminaires must be DALI compatible.
- 38.1.4 All internal and external light fittings (Luminaires) must meet or exceed the Energy Technology List (ETL) criteria.
- 38.1.5 All luminaires shall be mounted so as to be accessible for maintenance using a 1.8m step ladder used by a single operative. The designer shall ensure that this is so and take into account likely or proposed furniture and equipment layouts. Where luminaires are located at roof level or in similar situations they shall be accessible to a 1.5m individual without steps or other equipment.
- 38.1.6 The designer shall clearly state energy class of each discrete part of the proposed lighting installation in accordance with the requirements of BS EN 15193. This shall include daylight dependency factor, occupancy factor and constant illuminance factor. A LENI of 3,5kW/h/m²/year should be achieved.
- 38.1.7 All lighting circuits shall be so arranged that all lighting controls, chargers etc. are fed via the relevant lighting circuit and lighting circuits shall be metered by groups. All parasitic lighting loads shall be captured in this metering.
- 38.1.8 Provide LED luminaires as first choice. Where prior written approval for fluorescent luminaires has been obtained from PAF Operations Department luminaires shall be complete with control gear of the high frequency electronic ballast type, with power factor correction to a minimum of 0.85 lagging, and fused terminal block. Lamps shall be 40,000 hour 3500k.
- 38.1.9 The designer shall provide the City University Operations Department with a full life cycle costing analysis to justify recommendation for non LED type luminaires. This is to include capital, installation, maintenance, energy and disposal costs.
- 38.1.10 Ensure lighting equipment and installation is suitable for safe and permanent operation in the conditions to be encountered in service.

38.2 Luminaire Installation

- 38.2.1 Supply, erect, and connect all luminaires complete with all glass ware, diffusers, lamps, appropriate control gear and where necessary gasket seals. Ensure that Luminaires/lighting installations comply with the requirements of all relevant Standards.
- 38.2.2 Fix every surface mounted luminaire to a conduit box (or boxes) which shall have Flex 7 connectors.

- 38.2.3 Fix all luminaires and pendants with brass roundhead screws.
- 38.2.4 Provide all pendant luminaires with suspension system and associated flexible cable to a maximum length of 600 mm unless otherwise defined elsewhere.
- 38.2.5 Ensure flexible cables to pendant luminaires are 300/500 volt grade to the relevant Standards, LS0H insulated white circular, with HC tinned copper conductors of minimum size 1.5mm².
- 38.2.6 Ensure the maximum mass of any suspended luminaire is 3kg unless additional support is provided.
- 38.2.7 Use heat resistant flexible cables for all non-pendant type luminaires.
- 38.2.8 Provide fixing to, or suspension from lighting trunkings in accordance with manufacturers recommendations and the Specification.
- 38.2.9 Connect all metalwork on luminaires to the circuit protective conductor with proper and approved earthing arrangements for metalwork.
- 38.2.10 Do not permit luminaires which are fixed onto, or recessed into suspended ceilings to have their weight borne by the ceiling unless written approval is obtained. Suspend luminaires from the structure or ceiling beams over. Use steel strapping, circular steel suspension, conduit suspension or proprietary fixing methods. Two fixings at least are required for luminaires up to 300mm wide and four fixings for sizes over 300mm wide.
- 38.2.11 Provide plug in Flex 7 connections, complete with plug for each recessed luminaire installed in a suspended ceiling and for plant room lighting. Install in a convenient accessible position to facilitate the removal of the luminaire. Ensure flexible cables between plug-in sockets do not exceed 600mm long.
- 38.2.12 Supply and fix all fixing and suspension materials.
- 38.2.13 Where no access above the ceiling is provided wiring to suspended luminaires shall enter through a rigid conduit suspension.
- 38.2.14 Ensure the luminaire backplate fully covers the conduit box in concealed installations. Use white break joint rings where the conduit boxes cannot be concealed by the luminaire backplate
- 38.2.15 Do not use luminaires for through- wiring unless the luminaire is specifically designed for that purpose and incorporates a segregated wiring channel. Ensure final circuit wiring enters each luminaire at position corresponding to fused terminal block location in luminaire.
- 38.2.16 In the case of recessed luminaires and heat producing/emitting, equipment having final connections effected using flexible cables, make the final connections using heat resistant flexible cables.
- 38.2.17 Where cables are permitted to traverse channel-ways or similar on continuously mounted fluorescent luminaires, use heat resistant cables throughout.
- 38.2.18 Where lampholders are required, ensure these are heat resisting and comply with the relevant Standards.
- 38.2.19 Provide ceramic interiors for screw type lamps and when used in Class 4 areas.
- 38.2.20 Provide brass lampholder with ceramic interiors when integral with luminaires.

- 38.2.21 Provide white plastic with compression cord grip with flexible pendants, skirted or shrouded.
- 38.2.22 Ensure batten lampholders are heat resistant and skirted.
- 38.2.23 Ensure metal lampholders are effectively earthed using an earth terminal fixed to the lampholder by the manufacturer.
- 38.2.24 Provide ceiling connections for all lighting points with a luminaire suspended by a flexible cable without an integral mounting.
- 38.2.25 Ensure ceiling roses conform to the relevant Standards, of the white insulated pattern incorporating 2, 3, or 4 terminals, as necessary, complete with cord grips.
- 38.2.26 Ensure all lamps are new at handover, allowing reasonable time for testing etc.
- 38.2.27 "Break-in" fluorescent lamps used on dimming circuits for at least forty hours.
- 38.2.28 Thoroughly clean luminaires after installation, leaving the installation in a new, clean condition at handover. Do not use the permanent lighting installation for temporary lighting purposes during the contract period unless prior written approval is obtained from City University Operations Department.
- 38.2.29 Ensure correctness of luminaires for the type of installation, location, lamp, voltage, ceiling void size (including tee ceiling section size and type of ceiling systems etc.). Liaise and co-ordinate luminaire installation with ceiling erector.

38.3 Wiring Installations

- 38.3.1 Arrange lighting distribution, on radial final circuits from dedicated lighting distribution boards. Minimise effect of circuit failure of the lighting circuits for plant room areas, circulation areas, corridors, etc., so that failure of one circuit will only cause the loss of a maximum of half the luminaires in that particular area. Use Flex 7 system for final connections to luminaires.
- 38.3.2 Carry out the lighting installation using LSOH insulated copper cables installed within rigid steel conduits and trunking in accordance with the requirements indicated in the Specification, unless detailed in the Particular Project Specification.

38.4 Lighting Control

- 38.4.1 Refer also to the City University London Lighting Control Specification.
- 38.4.2 Agree all lighting control requirements with City University Operations Department prior to commencing design and/or installation. No closed protocol systems will be accepted.
- 38.4.3 Lighting control switches including dimmers must be robust and fit for purpose. Lighting control switches must be straightforward and simple to use without special knowledge or training.
- 38.4.4 Generally lighting control by means of centrally monitored KNX is preferred. Areas such as plant rooms and where machinery is in use shall use conventional switching under user control. Luminaires in these



areas shall not have DALI control gear. With prior written authorisation by PAF Operations Department small installations can be controlled by local stand-alone movement and day light controls.

- 38.4.5 All projects must have a clearly stated lighting control philosophy to be approved by City University Operations Department.
- 38.4.6 Emergency test switches must be easily accessible, maximum 1500mm AFFL, clearly identified and labelled engraved red
- 38.4.7 Provide control to lighting installations be means of manual switch control in accordance with the requirements of the Specification. Arrange luminaire, final circuits and switching arrangements as indicated in the Particular Project Specification and/or on the project drawings.
- 38.4.8 Use automatic lighting controls where indicated in the Particular Project Specification and detailed on the drawings.

38.5 Lighting Levels

- 38.5.1 Levels of illumination shall be sufficient for the particular operations or movements. Use the recommendations of the relevant Standards, for all lighting design and installation criteria. Agree each particular project lighting requirements with City University Operations Department. At commissioning, maximum lighting levels shall be adjusted as stated below.
- 38.5.2 Generally lighting levels should be as follows:-
 - a) Offices / Lecture Theatres / Meeting Rooms – should be 350-400 lux at desk level.
 - b) Corridors / toilets – 100 lux min at floor level.
- 38.5.3 Engineering prior to commencing design and/or installation.
- 38.5.4 Limit glare, to the recommendations of the relevant Standards in special cases, (Computer Rooms, VDU areas, instrumentation). Provide for lighting installation/design to reduce reflections to acceptable minimum standards in accordance with lighting standards, codes and guides.

39 EMERGENCY LIGHTING

- 39.1.1 Ensure that, where applicable, the diffuser material of any emergency luminaire, complies with the requirements of the relevant Standards e.g. Where installed on means of escape routes etc.
- 39.1.2 Ensure that emergency lights are of a noise free type and only give visual indication of fault.

39.2 Emergency Luminaire Systems

- 39.2.1 Ensure the types of system(s) used for a particular project comprise the following minimum appropriate requirements:-
- 39.2.2 Provide self-contained luminaires complete with lamps, legends (where required for exit signs) nickel cadmium batteries (suitable for temperatures up to 50°C) of a 3-hour duration period, charger, red light emitting diode (mains healthy) and mains sensing devices. Ensure operation of various types of systems comply as follows:-
- a) Non-maintained - emergency light 'Off' and battery on automatic charger when 'mains' supply is healthy. The luminaire lamp shall automatically switch 'On' when 'mains' is interrupted and powered by battery.
 - b) Maintained - emergency light 'On' and battery on automatic charge when 'mains' supply is healthy. The same luminaire lamp remains 'On' powered by the battery when the 'mains' supply is interrupted.
 - c) Sustained - normal 'mains' powered lamp 'On' and battery on automatic charge when 'mains' is healthy. Separate emergency lamp is automatically switched 'On' when 'mains' supply is interrupted.

39.3 Self Contained Emergency Lighting

- 39.3.1 Ensure control gear for fluorescent luminaires is complete with charger/inverter module (of appropriate rating), battery pack and wired to suit maintained or non-maintained emergency use.
- 39.3.2 Provide the above components, fitted/wired within the selected luminaires, by the luminaire manufacturers. Take care to keep components away from hot devices.
- 39.3.3 Provide charger indication of the red light emitting diode type, within each luminaire.
- 39.3.4 Emergency, self-contained battery handlamps shall be provided in the substation, and switchrooms, in addition to normal emergency lighting. Allow for 3 No. handlamps and charger for wall mounting of a type and specification agreed with City University Operations Department.

39.4 Central Battery Emergency Lighting

- 39.4.1 Ensure central battery system(s) are of the battery cubicle type, of the rating defined for the particular project. Allow the complete connected emergency system to operate for at least three hours in the event of 'mains' failure. Ensure each battery cubicle contains the following minimum equipment:-
- a) Suitably rated battery charger of the solid state constant voltage type, with self-protecting current limiting, for protection against low battery voltage and short-circuit protection.
 - b) Suitably rated load contactor arranged to change over to battery operation in the event of mains failure.
 - c) Transformer rectifier circuit with d.c. smoothing.
 - d) Suitably rated 'mains' and 'control' fuses.
 - e) Phase failure relay, connected to the incoming SP or TP&N supply or the designated source(s) to be monitored.
 - f) Alarm indicators mounted on the front of the panel for the following: high and low voltage, charger failure alarm and a common volt-free contact to operate when any of the alarms are initiated for remote fault indication
 - g) Voltmeter with 'load' and 'charge' ammeters shall also be included.
 - h) Where designated, a SP&N distribution board with 20% spare ways, installed complete to serve local emergency lighting distribution boards. Refer to LV Supply section of the Specification.
 - i) Isolating switches, provided on the cubicles to enable the maintained lighting supplies to be isolated when required.
 - j) Panel internal wiring.
- 39.4.2 For maintained systems, ensure cubicle encloses double wound transformer (with earth screen) wired to normally open contacts of the contactor controlled by its own switch.
- 39.4.3 Ensure where local emergency lighting distribution boards are used, these are of the appropriate patterns compatible with the system source, voltage etc. and fitted complete with local isolator/contactor and remote control relays where remote monitoring is required for the particular project.
- 39.4.4 Ensure the central battery system is a central Sinewave Inverter system operating at an inverted 240 volts AC fed from a 415 AC supply.
- 39.4.5 Do not take delivery of the batteries until the complete system is ready for test.
- 39.4.6 Agree the allocation of the batteries with the manufacturer to ensure there are no delivery problems. Ensure the batteries, when delivered, are new batteries and not batteries set aside by the manufacturer for the project.

- 39.4.7 Provide the central battery emergency lighting system with a 240AC maintained output, central inverter unit feeding general lighting fittings via separate emergency lighting distribution boards. Ensure in this way, full light output from selected luminaires is available for emergency use for up to three hours following failure of the mains supply/standby generator.
- 39.4.8 Locate sine wave inverter unit in the LV switch room or alternative location agreed with City University Operations Department for the particular project requirements.
- 39.4.9 Provide the central battery cubicle with sealed lead acid batteries requiring minimum maintenance and giving a minimum 8 year operational life under normal operating conditions, as required in the relevant Standards.
- 39.4.10 Provide N/O, volt free common alarm contacts in the inverter cubicle, linked to the SCADA system for the particular project.
- 39.4.11 Ensure all system wiring for emergency lighting is MICC/LS0H (white), as detailed in 'Cabling Systems' of the Specification.
- 39.4.12 Provide final connections to each luminaire via plug and socket facilities for ease of maintenance, wired in butyl flex, connected via a hold-off relay. Ensure all circuit conductors are disconnected, and where two separate supplies are present, provide a suitable warning notice with details of circuits to isolate.
- 39.4.13 Provide local test key switches in conjunction with normal light switches having neon and audible buzzer facilities to simulate local mains failure. Ensure the hold-off relay associated with emergency designated luminaires illuminate the fittings either by normal mains or battery inverter maintained output derived from the central battery unit in the advent of total mains failure.
- 39.4.14 Provide emergency luminaires generally capable of operating as maintained units. Ensure the local switching provides lighting illumination throughout all areas.
- 39.4.15 Design/install the central battery unit to be capable of operating all emergency luminaires indicated upon the particular project drawings together with 20% spare capacity. Confirm the total load of luminaires selected. Ensure that the size of central battery unit is adequate to comply with the Specification.

39.5 Central Battery Operation

- 39.5.1 Ensure during main supply healthy conditions, the load is supplied from the normal mains AC supply. Provide for the inverter unit and power circuit to be energised and 240V AC present at each distribution board and on each circuit, but no load taken.
- 39.5.2 Arrange in the event of a supply failure, the hold-off relays to changeover the supply to the emergency luminaires load, from normal mains to sine wave inverter supply.
- 39.5.3 Ensure when the normal mains supply is restored, the hold-off relay coil is energised and the contact changeover occurs, the supply to the emergency luminaires, reverts back to the normal mains supply.

39.6 Cubicles

- 39.6.1 Provide separate units for the charger/inverter and the batteries.



39.6.2 Ensure each cubicle section has its own hinged lockable door.

39.7 Sine Wave/Charger/Inverter/Module

39.7.1 Determine output for each particular project to give 3 hours at 240V AC+/- 2%, 50Hz single phase

39.7.2 Total Harmonic Distortion (THD)-Less than 5%

39.7.3 Overload-50% for 10 seconds at full output voltage. 20% for 30 seconds.

39.8 Instruments

39.8.1 Provide the following instruments and indicators:-

- a) Power On.
- b) Charger Current Limit.
- c) Inverter running
- d) Voltmeter - Mains Input and Inverter Output.
- e) Ammeter - Mains Input and Inverter Output.
- f) Kilowatt - Mains Input and Inverter Output.
- g) Battery low volts.
- h) Battery high volts.
- i) Charger Failure.

39.9 Alarms

39.9.1 Provide the following alarm circuits with full audio and visual indication.

- a) Battery low volts
- b) Battery high volts
- c) Charger failure
- d) Common alarm - to be interfaced to SCADA with 2 No. N/O volt free contacts.

39.10 Distribution

39.10.1 Integral to the cubicles shall be a distribution board as detailed for the particular project. Include an isolator, and outgoing circuits, protected by suitably rated circuit breakers (MCB's).

39.10.2 Include for mounting the board flush within the cubicle.

39.10.3 Include for co-ordinating positioning of board and all incoming outgoing cables.

39.10.4 Provide each battery cubicle, connected to the mains source, controlled by a suitable multi-pole isolator mounted adjacent the respective cubicle. Provide final connections enclosed in flexible conduit.

39.11 Emergency Luminaire Installation and Testing

39.11.1 Provide final connections to emergency luminaires in accordance with the following:-

39.11.2 Self-contained luminaires to be via concealed Flex 7 connector or in the case of wall-mounted units, fuse connection units. Provide final connections with multicore butyl flexible cable of the appropriate size indicated in the General Lighting Section of the Specification.

39.11.3 Integral control gear to be via Flex 7 connector outlet of different pattern to conventional 3-pin ceiling roses, mounted adjacent to 'mains' connection arrangement controlling 'mains' supplies to luminaires. Provide final connections with multicore butyl flexible cable of the appropriate size indicated in 'General lighting' Section of the Specification. Provide appropriate warning labels, fitted externally to luminaires stating emergency source connection. Provide pin configuration for Flex 7 connector as follows:-

- a) Pin 1 - switched live
- b) Pin 2 – neutral
- c) Pin 3 - earth (separate CPC)
- d) Pin 4 - unswitched live

39.12 Testing

39.12.1 Following a 100% contractor / consultant witness test, offer the total emergency lighting installation(s), for testing at their discretion, in the presence of City University Operations Department and their appointed Fire Officer, together with 100% sign off documentation, confirming the whole installation is in accordance with the equipment manufacturers' recommendations and the requirements of the relevant Standards.

39.12.2 Provide, upon satisfactory completion of the above tests, the equipment manufacturers and installation completion/test certificates for the system, as outlined in the relevant Standards.

39.12.3 Provide for completing all required commissioning and system demonstration tests to the Specification of City University Operations Department. Allow a minimum of 10 days' notice of the proposed test dates to enable City University Operations Department / Fire Officer to witness tests.

39.12.4 Provide a full system load test to verify operation of all emergency luminaires for the required battery support period of 3 hours, followed by full recharging within 24 hours.

- 39.12.5 Provide for all tests to be fully recorded and issued with the 'As Fitted' drawings and operating and maintenance manuals, as detailed in 'Testing' section of the Specification.
- 39.12.6 Ensure all positions, numbers and types of installed emergency luminaires are detailed on the 'As Fitted' drawings and in the operating and maintenance manuals.
- 39.12.7 Provide for central battery emergency lighting systems the following additional testing requirements:-
- 39.12.8 Prior to connecting the sine wave inverter to the distribution system perform full load test using a resistive load bank suitable to prove the ampere hour capacity of the batteries.
- 39.12.9 Record the outgoing volts and amps at 5 minute intervals up to 3 hours. Take the first readings before the main isolator is closed and then immediately after at periods of one minute up to 5 minutes.
- 39.12.10 Reset the system at the end of the test and prove recovery time of batteries.
- 39.12.11 Test whole system, with luminaires installed, by interruption of the mains supply to the luminaires. Include testing each key switch operation and also a full load test at the main isolator for the full 3 hour duration.
- 39.12.12 Record outgoing voltage and current readings at 5 minute intervals. Take first reading before the load is connected, the second immediately after the load is connected, and then at 1 minute intervals for the first 5 minutes.
- 39.12.13 Carry out the functional tests with manufacturer to fully satisfy functional operation of system before demonstration of the complete system to the satisfaction of City University Operations Department. Provide full method statements for the demonstration.
- 39.12.14 Issue fully tabulated test results prior to the demonstration for comment by City University Operations Department prior to inclusion in the Operation and Maintenance Manual.
- 39.12.15 All installed emergency luminaires shall be labelled to identify the floor and luminaire number which shall cross reference to the as installed drawings. Numbering system is to be agreed with City University operations Department.

39.13 Wiring Installation

- 39.13.1 Ensure the wiring installation to be used for emergency lighting are as defined in the appropriate part of 'Cabling Systems' of the Specification and are identified and segregated from other circuits as defined in the Specification.
- 39.13.2 Ensure that, where no specific wiring installation is specified, then it shall be of the appropriate type design and installation as defined in the relevant Standards.
- 39.13.3 Ensure where 'central' battery systems are to be installed the cable sizes are a minimum of 2.5mm² as referred to in 'Cabling Systems' of the Specification.
- 39.13.4 Ensure, where luminaires are connected to a central battery system(s), that the conductors are colour coded for ease of identification and fully segregated from other services, as detailed in the Specification.
- 39.13.5 Ensure non-maintained emergency luminaires are installed with the 'mains' unswitched live connection fed from the appropriate final circuit MCB/fuse, of the designated general lighting distribution board.



39.14 Emergency Lighting Control

39.14.1 Provide test switches to operate emergency luminaires. Use the same type/pattern as normal lighting switches but of key action. Ensure wherever possible, the key switches are mounted on the respective multi-gang plate of the 'local' lighting control switches. Ensure all emergency lighting test switches are engraved with the final circuit reference and "EMERGENCY LIGHTING TEST".

39.15 Lighting Levels

39.15.1 Carry out design of lighting levels for all emergency lighting systems in accordance with the recommendations of the relevant Standards and to suit the particular project requirements.

40 EXTERNAL LIGHTING

- 40.1.1 Provide, where specified for the particular project, complete exterior lighting systems including supply and erection of all poles, columns and brackets.
- 40.1.2 Give preference to free standing columns to suit the particular project. Fix, where applicable, luminaires to structures and buildings.
- 40.1.3 Ensure all luminaires and controls are finally adjusted and aligned to provide a uniform illumination of the area covered .
- 40.1.4 Ensure luminaires mounted on buildings, have the wiring routed within the building.
- 40.1.5 Provide all columns of flange base type suitable for fixing to concrete foundations.
- 40.1.6 Ensure columns are bonded to earth. Provide column bases with weatherproof access doors with tamperproof locks.

40.2 External Luminaire Installation

- 40.2.1 Provide all external luminaires as required for the particular project complete with columns, fused cut-outs, control gear, mounting brackets, fixing clamps, interconnection, spigot, lamps, tools etc. as appropriate.
- 40.2.2 Ensure where luminaires are column or bracket mounted, allow for column, brackets and visible accessories to be painted by manufacturer to a RAL colour to be agreed with City University Operations Department .
- 40.2.3 Agree all external lighting requirements with City University Operations Department prior to commencing design and/or installation.
- 40.2.4 Exercise care in the positioning of external luminaires to avoid the possibility of glare to CCTV cameras serving adjacent areas or the particular project.

40.3 Wiring Installation

- 40.3.1 Provide wiring installations to the external lighting for each particular project, in accordance with 'Cabling Systems' of the Specification, and in accordance with the project design requirements.
- 40.3.2 Ensure that generally, below ground cables originate from external lighting distribution boards and are run via underground pipe ducts to draw pit locations close to the luminaires positions.
- 40.3.3 Ensure all cables not enclosed in pipe ducts are protected by cable tiles with marker tape and route markers, as detailed in 'Cabling Systems' of the Specification.
- 40.3.4 Ensure wiring to column mounted luminaires is buried PVC/SWA/PVC cables as detailed in 'Cabling Systems'.



- 40.3.5 Ensure the cable is looped to terminal/fuse units mounted in the bases of the columns. Provide suitable brackets for fixing the cable glands in the column bases. Ensure connections from the terminal/fuse units to the luminaire are PVC/PVC cable with earth protective conductor.
- 40.3.6 Provide 3 core, copper, PVC/SWA/polythene sheathed cable where high water table levels occur. Use the third core as the protective conductor.

40.4 External Lighting Control

- 40.4.1 Provide solar dial quartz type time switches with battery reserve incorporated with a main external lighting control panel. Provide photocell control where required for each project and where agreed with City University Operations Department e.g.. vehicular road/access lighting, site street lighting, car park lighting.
- 40.4.2 Provide override switches in locations agreed with City University Operations Department for each project or other designated location. Ensure operation in conjunction with solar dial time clocks to control external lighting distribution board contactors (on and off).
- 40.4.3 Provide separate MCB distribution boards for external lighting controlled by contactors, for all external lighting final circuits in accordance with the particular project requirements.

40.5 Lighting Levels

- 40.5.1 Carry out design of lighting levels for all external lighting systems in accordance with the recommendations of all relevant Regulations, Standards, Codes of Practice and to suit the Particular Project Requirements.
- 40.5.2 Agree all lighting levels with City University Operations Department.



LV POWER

41 GENERAL LV POWER

41.1 Isolators / Switches

- 41.1.1 Generally all wiring accessories shall be white MK Logic Range, cleaners sockets shall be grey or other approved distinguishing colour and clearly labelled – from their own circuit supply and marked as cleaners. In plant and service areas MK metalclad wiring accessories shall be used.
- 41.1.2 Ensure double pole and triple pole and neutral control switches are in accordance with relevant Standards (Category AC22) respectively and are matched with other accessories defined in the Specification. Note that the requirement is for two pole and four pole devices.
- 41.1.3 Ensure each switch is of the surface or flush pattern as appropriate and install with suitable box and earth fly-lead.
- 41.1.4 Ensure switch plates are complete with pilot lamp, and as defined in the Specification, labelled and engraved with coloured lettering identifying the equipment being controlled.
- 41.1.5 If cable outlet plates are required for final connections to equipment, match these to correspond with other accessories.
- 41.1.6 Ensure local lighting switches comply with the manufacture, rating and type as indicated in the Particular Project Specification requirements or on the drawings.
- 41.1.7 Ensure switches are capable of switching the full rated inductive or resistive load, and where connected to fluorescent loads in excess of 600 watts, use 15 amp rating.
- 41.1.8 Install all switches with boxes of 35mm minimum depth with adjustable lugs to ensure switchplates are true and square where required. Fit boxes flush with wall finish and make any adjustment to depth with extension rings.
- 41.1.9 Ensure all switch boxes are compatible with the wiring system used and are complete with CPC terminal.
- 41.1.10 Where several switches of the same phase are required in the same position, use a multi-ganged switch box to accommodate all switches on a common faceplate.
- 41.1.11 Where switches are specified for Class 4 installation in situations exposed to weather, or continual dampness, ensure they are of the weatherproof pattern in accordance with the relevant Standard and minimum IP65 rating.
- 41.1.12 Where different phases are present at one switch location, segregate each phase in a separate compartment and cover each compartment by its own internal warning plate suitably engraved. "WARNING 400 VOLTS PRESENT".
- 41.1.13 Mount switches adjacent the closing stile of doors where possible.

41.2 Socket Outlets

41.2.1 Low Voltage 230V:-

41.2.2 Ensure socket outlets comply with the relevant Standards, switched and shuttered, and mounted in single or multi-gang assemblies, and are of the type and rating as indicated in the Particular Project Specification or on the drawings. Where outlets are to be floor mounted they shall be as MK 740BSS or 742BSS. Floor mounted data outlets shall be presented using MK 790 BSS or 795BSS.

41.2.3 Fit MK Tough Plug plug tops to appliances with fuses of the correct rating.

41.2.4 Install all socket outlets with boxes not less than 35 mm deep with adjustable lugs to ensure socket plates are true and square. Where required, fit boxes flush with finished surface (e.g. floors, skirtings or walls) and make any adjustments to depth using extension rings.

41.2.5 Ensure all socket outlet boxes are compatible with the wiring system used and are complete with CPC terminal. Ensure cover plate finish match the lighting switches, flush or surface to suit the mounting box, and with all other general LV power accessories.

41.2.6 Ensure the earth pin of each socket is connected to the box earth terminal with a green/yellow insulated protective conductor. Do not use cover screws for earth continuity.

41.2.7 Use indicating pattern outlets for appliances with a heating element.

41.2.8 Where socket outlets are specified for Class 4 installation in situation exposed to weather or continual dampness, ensure that they are of the weatherproof pattern in accordance with the relevant Standard and minimum IP65 rating.

41.2.9 Ensure all sockets are suitable for safe and permanent operation in the conditions to be encountered in service. Non-standard socket outlets shall be utilised for UPS supply connections where indicated in the Particular Project Specification or on the drawings.

41.3 Low Voltage Three Phase Switched Socket Outlets

41.3.1 Use MK 32A, 3 phase, 4 wire, 5 pin switched socket outlets with lock off or single phase 3 wire, 3 pin switched socket outlets with lock off for use with all portable equipment up to and including 32A rating. Outlets shall be single phase for single phase equipment and three phase for three phase equipment, as required. Single phase equipment shall not be fed from three phase outlets.

41.4 Reduced Voltage Socket Outlet (for portable tools and equipment)

41.4.1 Use MK composite units, unless otherwise stated, comprising a 230 to 110 volt toroidal transformer with 230 volt and 110 volt socket outlets with integral RCD protection.

41.5 Freezer Alarm Socket Outlets:-

41.5.1 Use specially fabricated 3 pin and earth, 16A socket outlets to the relevant Standards, for the freezer alarm socket, and together with an associated local alarm panel. Alarm panel shall have sufficient alarm



channels for the number of freezer points required, plus 50% spare capacity. Manufacture units in accordance with drawing included in the Specification.

41.6 External Socket Outlets and Equipment

- 41.6.1 Note that the term "External Socket Outlet and Equipment" applies to any socket outlet or equipment which itself is located outside the equipotential bonding zone of the main electrical installation or provided for the specific purpose of enabling mobile or portable equipment to be used outside this zone.
- 41.6.2 Protect all external socket outlets by a residual current device (RCD) having an operating current not greater than 30mA.

41.7 Fused Connection Units.

- 41.7.1 Ensure these are to the relevant Standards, double-pole switched or unswitched insulated patterns, with plates to match the socket outlets.
- 41.7.2 Where used as a flex outlet for an appliance, ensure they are of the flex outlet pattern with cable anchoring clamp.
- 41.7.3 Fit fuses of the correct rating.
- 41.7.4 Install fused connection units with boxes not less than 35 mm deep with adjustable lugs to ensure the connection unit are true and square. Fit boxes flush with the wall finish and make any adjustment to depth using extension rings.
- 41.7.5 Ensure all boxes are compatible with the wiring system used and are complete with CPC terminal.
- 41.7.6 Ensure the earth connection of the connection unit is connected to the box earth terminal with a green/yellow insulated protective conductor. Do not use cover screws for earth continuity.

41.8 Local Isolation

- 41.8.1 Local isolators shall be IMO enclosed 69 series type isolating all phase conductors and neutral with padlock off facility suitable for CU Safety Locks.

41.9 Wiring Installations

- 41.9.1 Carry out all wiring installations for the general LV power installation in accordance with the appropriate sections of the Specification and where the type of wiring installation is indicated in the Particular Project Specification.
- 41.9.2 In general provide LV power outlet distribution on radial circuits from dedicated small power distribution boards. Protect each circuit by a 30mA RCD unless otherwise specified. Carry out LV power final circuit wiring using PVC insulated copper cables installed within steel conduits and trunking in accordance with the Specification.



- 41.9.3 Submit full details of all proposals for small power installations to City University Operations Department, for comment. Agree locations of all outlets with City University Operations Department prior to the design and/or installation commencing.
- 41.9.4 Use flexible cables for final connections to equipment (fixed or portable). Ensure these are 300/500 volt grade to the relevant Standards using LS0H insulated white circular cable, with HC tinned copper conductors of minimum size 1.5mm².
- 41.9.5 Use heat resistant flexible cables for making final connections to equipment (fixed or portable) with a heating element, or equipment fixed to pipework or appliances forming part of a heat distribution system; ensure the flexible cables are 300/500 volt grade complying with the relevant Standards.

42 ELECTRIC HEATING / FROST PROTECTION

42.1 Trace Heating

- 42.1.1 Provide trace heating equipment to facilitate freeze protection for wet containment and storage systems, where contained fluid could be exposed to freezing conditions (below 5°C). Details of identified risk and proposed design solution to be submitted to City University Operations Department before installation works commence.
- 42.1.2 All trace heating elements to be of energy efficient self regulating type manufactured, designed and installed to the relevant Standards.
- 42.1.3 Identification of the freezing risk for external systems to include for wind chill factors of 10 metres/second. Any proposed design to be based on an ambient air temperature -20°C.
- 42.1.4 Any designed systems to be compatible with 230Vac \pm 10% 50Hz supply and shall have 30mA/30ms RCD circuit protection. Devices protecting trace heating installations shall be fitted with auxiliary contacts connected to the SCADA system arranged so as to generate an alarm in the tripped or off positions.
- 42.1.5 Wherever trace heating is installed, identification warning labels shall be applied with a minimum frequency of one label every 5m of tape length.
- 42.1.6 Trace heating tapes to be installed using only proprietary fixing methods and accessories.
- 42.1.7 In the design of any trace heating system, also take the following into account:-
 - a) Protection of components with higher heat losses e.g. valved connections.
 - b) Additional efficiency by use of ambient or in line thermostatic control.

42.2 Space Heating

- 42.2.1 Space heating using electricity should be avoided if at all possible. If the Contractor or designer wishes to incorporate electric heating then approval in writing must be obtained from City University Operations Department who will require full justification.
- 42.2.2 Storage radiators on combined thermostatic and time clock controlled circuits are the preferred method of using electricity for space heating. Ensure radiators are fixed using fibre wall plugs.

43 MOTORS

43.1 General

- 43.1.1 Ensure the electrical supply to motors is 3-wire 400V (+10/- 6%), 3-phase, 50Hz, or 2-wire, 230V (+10/- 6%), 1-phase, 50Hz.
- 43.1.2 Motors
- 43.1.3 Ensure, unless otherwise indicated, all motors are suitable for use in ambient temperatures up to 40°C and relative humidities up to 90%. Provide motors proofed against atmospheric corrosion, including that of saline air where applicable.
- 43.1.4 Install all motors with a suitable 'on load' isolator with 'lock off' facilities, two, three, six, nine or twelve as necessary to suit motor wiring, metal shaft and fully shrouded auxiliary terminals located adjacent to the motor for maintenance, isolation and functional switching purposes in accordance with the relevant Standards. Provide emergency stop buttons, fitted with stay-put non self-resetting facilities, where agreed with City University Operations Department.
- 43.1.5 Agree requirements for anti-condensation heaters, where appropriate, with City University Operations Department.

43.2 Three Phase Motors

- 43.2.1 The use of motors other than high efficiency types (minimum IE3) must be justified in writing to City University Operations Department .
- 43.2.2 All motors to be totally enclosed fan cooled (TEFC) type and protected against dust and water ingress to IP55.
- 43.2.3 Motor insulation to Class 'F' and motor designed temperature rise to be within Class 'B', designed for safe operation at maximum continuous rating and within the electrical supply parameters defined in the Specification or for the particular project..
- 43.2.4 Ensure all motors are designed for continuous running duty (S1).
- 43.2.5 Provide single speed motors as 4-pole 1500 rpm type, except where specified otherwise or agreed with City University Operations Department.
- 43.2.6 Motors with ratings of less than 3kW shall have three terminals, motors with ratings of 3kW or greater shall have six terminals to permit star delta starting.
- 43.2.7 Select a starting method that limits the volt drop when the motor starts to 1% at the point of common coupling with the site distribution system, notwithstanding the 1% limit where the motor is fed from a MCC then a limit of 3% may be used however where the MCC is connected to the site distribution network the 1% limit applies at that point. The designer shall produce such calculations to demonstrate compliance with this requirement. Select assisted starting from one of the following:-
- 43.2.8 - Star/Delta Starter

- 43.2.9 - Closed transition auto-transformer (Korndorfer)
- 43.2.10 - Electronic Soft Start, it is essential that the current control loop is the primary control.
- 43.2.11 - Variable speed drive, it is essential that the current control loop is the primary control.
- 43.2.12 Identify requirements for the particular project, of the use of alternative starting methods, frequency invertors or other variable speed drives. Agree equipment requirements with City University Operations Department.
- 43.2.13 Ensure dual speed motors have separate windings for each speed.
- 43.2.14 Provide thermal overload protection for all motors of 0.37kW and above, for all motors enclosed in ductwork and for other motors where specified for the particular project. Provide thermal protection to motors in hazardous areas and to motors with full load currents in excess of 80A by PTC type thermistors mounted in the motor stator end windings, one in each phase, and designed to trip at 160°C.
- 43.2.15 Provide the motor and/or electronic type overload and short circuit protection to motors in critical or particular applications, where agreed with City University Operations Department.

43.3 Anti-Static materials must be specified on drives in hazardous areas.

- 43.3.1 Provide motors of all metal construction, except that in motors of frame sizes up to and including D180 the internal fan may be of polypropylene or equal unless all metal construction is specified and agreed with City University Operations Department. Provide corrosion resistant paint finish.
- 43.3.2 Ensure motors are dynamically balanced to 'normal' balance standards defined by the relevant Standards.
- 43.3.3 Ensure motor frame sizes up to, and including, D200, have ball bearings at either end. Provide for motor frame sizes D225 and above, ball and roller bearings, the roller bearings being fitted at the driving end.
- 43.3.4 Ensure bearing housings are fitted with means to allow re-lubrication and to release any surplus grease so that it causes no damage or hazard.
- 43.3.5 Provide for final selection of the motor sizes by the motor manufacturer, submit the following data to the manufacturer in addition to that detailed in the Specification:-
 - 43.3.6 - Mechanical mounting details.
 - 43.3.7 - Direction of rotation.
 - 43.3.8 - Details of driven load, including speed of rotation and moment of inertia (kg m²).
 - 43.3.9 - Transmission method.
 - 43.3.10 - Details of duty for which required, including use of inverter where applicable, to control the speed.
 - 43.3.11 - Method of starting (e.g. soft-start).



43.3.12 Submit details of all motors ordered to City University Operations Department, for comment before manufacture begins.

43.4 Single Phase Motors

- 43.4.1 Single phase motors are supplied in some packaged units, e.g. small ventilation fans, by packaged unit manufacturers. Ensure starting and protection and control requirements are specified.
- 43.4.2 Provide single phase motors up to 0.37kW output for other services and to comply with the appropriate parts of Section 'Three Phase Motors' of the Specification.
- 43.4.3 Provide motors with capacitor-start, capacitor-run type, unless otherwise detailed for the particular project and agreed with City University Operations Department.

43.5 Medium Voltage Motors

- 43.5.1 Agree the use of medium voltage motors with City University Operations Department.
- 43.5.2 Determine Specification requirements for medium voltage motors in conjunction with City University Operations Department Electrical Engineering.
- 43.5.3 Starting arrangements for high capacity drives must be approved by City University Operations Department. A motor starting study will be required to demonstrate that the motor starting load will not affect other users on site or the Public supply.

43.6 Commissioning

- 43.6.1 Ensure motor drives are accurately aligned and tensioned as required by the belt drive manufacturer's instructions.
- 43.6.2 Ensure the main fuses are of the correct size for the motor full load current, the starting method and the frequency of operation.
- 43.6.3 Set starter overloads to the motor rating plate full load current.
- 43.6.4 Check thermistor relay operation (where fitted).
- 43.6.5 Measure and record with the motor delivering its maximum required duty the following:-
 - 43.6.6 - For 3-phase motors, each phase-to-phase voltage (400V nominal). For 1-phase motors measure phase-to-neutral voltage (230V nominal).
 - 43.6.7 - For 3-phase motors, each phase current. (Differences between any two phase currents of more than 5% indicates a possible fault to be investigated). For 1-phase motors measure line current.
 - 43.6.8 - Shaft speed.



43.6.9 Carry out all tests and commissioning procedures/requirements detailed in the relevant standards and regulations.

43.7 Inverters

43.7.1 Unless agreed in advance, in writing with City University Operations Department, all inverters shall be selected from the Danfoss VLT HVAC range



CONTROL AND INSTRUMENTATION

44 PACKAGED PLANT

- 44.1.1 All electrical equipment, materials and components must comply with the current edition of the relevant British Standard or European equivalent.
- 44.1.2 Standards which must be satisfied include;
 - 44.1.3 - Provision and use of work equipment Regulations (PUWER)
 - 44.1.4 - European Machinery Directive
 - 44.1.5 - Low Voltage Directive
 - 44.1.6 - EMC Directive
- 44.1.7 Equipment is to carry the appropriate CE marking. Certificates of Conformity and Incorporation, demonstrating compliance, are to be issued upon request City University Operations Department will advise on specific requirements if required.

44.2 Design Requirements

- 44.2.1 The electrical equipment must be designed to facilitate safe operation, inspection and repair.
- 44.2.2 Equipment must be suitable for continuous operation in the proposed location. Outdoor equipment must be of weatherproof construction, the minimum level of protection must be IP 55.
- 44.2.3 Equipment must be complete with all necessary service functions. General external lighting will normally be provided by others.
- 44.2.4 All conductors which may be live when the door is open must be protected and labelled to prevent accidental contact.
- 44.2.5 Control panel doors must be lockable. Two keys must be provided for each lock.
- 44.2.6 Precautions must be taken to avoid electrolytic corrosion between dissimilar metals used in the packaged equipment.

44.3 Hazardous Areas

- 44.3.1 Electrical equipment intended for use in potentially explosive atmospheres must be of EEx type. Unless stated elsewhere, the minimum level of protection required is EEx IIb T4. Type EExe enclosures are preferred in outdoor hazardous locations to preclude corrosion of flame paths. Copies of certificates must be provided for all hazardous area classified electrical equipment.

44.4 Enclosures

- 44.4.1 Unless specified elsewhere enclosures must be factory assembled from sheet steel, of sufficient strength and suitably protected for the intended environment. Outdoor panels must be fitted with an anti-condensation heater.
- 44.4.2 Ventilated panels incorporating heat producing equipment must be protected against humidity and dust accumulation. The minimum degree of protection for indoor ventilated panels must be IP33.
- 44.4.3 Door hinges must be inside the panel door lip.
- 44.4.4 Panels must be designed for full segregation between low voltage and safety low voltage equipment.
- 44.4.5 Small components must be mounted on DIN rails. All components must be accessible for inspection and testing.

44.5 Isolation and Safety Interlocks

- 44.5.1 Control panels must be provided with an effective means of complete isolation. The isolator must be a four pole, on-load combination MCCB The isolator operating shaft must be metallic.
- 44.5.2 The 'on' and 'off' positions must be clearly indicated with provision for padlocking in the 'off' position. The panel door must be interlocked with the isolator such that it is impossible to open the door in the 'on' or locked 'off' position.
- 44.5.3 Consideration may be given to housing SELV equipment in a separate compartment to facilitate testing.

44.6 BS 5304 Safeguarding of machinery.

44.7 BS 4794 Part 2 Position switches with positive opening.

- 44.7.1 Moving machinery that may cause injury to personnel must be guarded. Where guarding is removable for routine access, suitable interlocking must be provided to ensure that all power is removed from the machine, and that the machine is stationary before the guard can be removed. The interlocking system must ensure that power cannot be restored to the machine until the guard is correctly in place.

44.8 Control Equipment

- 44.8.1 Motor starters, contactor loads, etc. will normally be supplied via a motor control centre (MCC) located in a switchroom remote from the package. In certain cases, where for example there are complex control, interlocking and sequencing requirements, it may be preferable to include the starters in the packaged unit. The City University Operations Department will advise the preferred option.
- 44.8.2 Packaged units with local starters must be supplied complete. Requirements for motor starters are detailed in the MCC section of the electrical standard. An emergency stop button or local isolator must be provided adjacent to each motor if the distance between the starter panel isolator and any moving part associated with the motor or machinery exceeds 2 metres.
- 44.8.3 Control circuits external to the packaged equipment must operate at 110VAC or less, supplied from an integral power pack as described in the MCC section of the electrical standard.



44.8.4 Each electrical circuit/function in a packaged panel must be separately fused.

44.9 Indications

44.9.1 Indication lamps must be LED type. The City University Operations Department will advise the preferred type. Lamps must be replaceable without opening the panel door.

44.9.2 A door mounted ammeter, with suppressed upper scale suitable for motor starting must be provided for each starter. All ammeters must operate from a suitable current transformer. In-line ammeters are not acceptable.

44.10 Control Panel Wiring

44.10.1 The small wiring to be single core 600/1000V grade LS0H insulated stranded copper conductor to BS 6231. Minimum cable sizes :-

44.10.2 - Power circuit - 1.5 mm²

44.10.3 - Control circuit - 0.75 mm²

Control Panel – Cable Colours	
Mains voltage circuits (240 V / 415V)	
Phase 1	Brown L1
Phase 2	Black L2
Phase 3	Grey L3
Neutral	Blue
Control Circuits:	
110Vac Live	Yellow/Brown
110Vac Neutral	Yellow/Blue
24Vac Live	White/Brown
24Vac Neutral	White/Blue
+ 48Vdc	Orange/Red
- 48Vdc	Orange/Black
+ 24Vdc	White/Red Red
- 24Vdc	White/Black
CT wiring Phase L1	Violet/Brown
CT wiring phase L2	Violet/Black
CT wiring phase L3	Violet/Grey
CT wiring neutral	Violet/Blue
Earth Conductors	Green/Yellow striped
I.S Earth	Green/Blue striped

44.10.4 The outer sheath of multicore power and control cables must be black. All power, control and signal wires must be terminated using compression crimps.

44.10.5 Each end of every wire must be identified with ferrule type markers.

- 44.10.6 Plastic trunking must be used to contain internal panel wiring.
- 44.10.7 SELV wiring must be segregated from other voltages. If required the panel should be physically segregated to achieve segregation.
- 44.10.8 Panel and drawings to include a legend detailing wiring colours used and voltage.

44.11 Cabling

- 44.11.1 The package equipment supplier must supply, install and terminate all equipment interconnecting cables.
- 44.11.2 Equipment mounted cables must be adequately supported by heavy duty tray or racking. Support must be provided within the packaged unit for cables from remote equipment that are not part of the package.
- 44.11.3 Where necessary, equipment mounted cabling must be mechanically protected from damage.
- 44.11.4 Cables must be identified at each end with a proprietary cable marker.
- 44.11.5 Power and data cables must be sufficiently segregated to prevent interference between types of cable.

44.12 Cable Entry and Termination

- 44.12.1 Cables to motors and other loads from a remote MCC will be installed by others. Power supplies, control circuits, etc. must be marshalled to an agreed local interface box at the periphery of the package. Suitable segregation or separate junction boxes must be provided between different services and voltages.
- 44.12.2 At least 500mm must be provided at each cable termination point to allow for the bending radii of incoming cables.
- 44.12.3 Cable entry must be via a removable gland plates. Size and location of the gland plates must be clearly shown on the plant drawings.
- 44.12.4 For hazardous areas tapped holes must be provided suitable for certified cable glands. All unused entries must be blanked with a certified plug.
- 44.12.5 At least 200mm must be provided between the gland plate and the nearest associated terminal block.
- 44.12.6 Terminals must be of the 'Klippon' type or equivalent. A separate terminal must be provided for each conductor. An additional 15% spare terminals must be provided for all but the main incoming power terminals.
- 44.12.7 Terminals and conductors must be identified in accordance with the schematic diagrams. Permanent markers must be used. Adhesive markers are not acceptable.
- 44.12.8 Measuring circuit terminals must have provision for connecting a test instrument without disturbing the circuit terminals. Current transformer circuits must have a short circuiting link.
- 44.12.9 No in-line cable or wiring joints will be accepted.

44.13 Motors

44.13.1 All motors must be IE3 or better energy efficiency rating.

44.13.2 Thermistors must be provided for all motors in hazardous areas and for motors supplied via variable speed drives.

44.14 Earth Connections

44.14.1 Two connection points for earth bonding must be provided on the package suitable for M10 bolted connection.

44.14.2 All extraneous metalwork of the packaged unit must be bonded to the package main earth points.

44.14.3 Stranded copper conductors with an overall green/yellow sheath or tinned copper tape must be used for earth bonding. The minimum size of conductor for bonding panels must be 16mm² or the cross sectional area of the supply phase conductor whichever is the larger. Large items of plant must be bonded with 70mm² conductors.

44.14.4 Control panel doors, equipment plates, etc. must be earthed using a flexible copper braid, connected to a main earth stud close to the panel gland plate.

44.15 Anti-Static Precautions

44.15.1 Equipment for handling powders or non-conducting liquids must be designed to ensure that isolated metallic parts can not become charged due to the flow of the materials. City University Operations Department must be advised of proposals to control electrostatic charges before the equipment is delivered to site.



45 MCC PANELS

45.1 General

- 45.1.1 All Motor Control Centres supplied in accordance with this section of the specification to be Type Tested Assemblies (TTA) to BS EN 60439-1 Withdrawable type, unless stated otherwise in the project specification.
- 45.1.2 All electrical equipment, materials and components must comply with the current edition of the relevant British Standard or European equivalent.
- 45.1.3 Standards which must be satisfied include;
 - 45.1.4 - Provision and use of work equipment Regulations (PUWER)
 - 45.1.5 - Electricity at Work Act
 - 45.1.6 - European Machinery Directive
 - 45.1.7 - Low Voltage Directive
 - 45.1.8 - EMC Directive
- 45.1.9 Equipment is to carry the appropriate CE marking. Certificates of Conformity and Incorporation, demonstrating compliance, are to be issued upon request In general, provide for motors above 20kW, a form of reduced current starting.
- 45.1.10 Agree details with City University Operations Department.
- 45.1.11 MCC starter control options must be specified in the enquiry documents.

45.2 Enclosure

- 45.2.1 The high grade steel enclosure to be a minimum of 2mm thick and be machine folded/welded or bolted modular assembly.
- 45.2.2 Suitable separation by internal rigid barriers/partitions to meet the requirements of Form 4 type 7 for front and rear access boards.
- 45.2.3 Connections from the busbars to the live side of functional units to be adequately shrouded/separated in the associated compartment.
- 45.2.4 Arrange adequate accommodation for outgoing circuits, sufficiently separated from interconnections etc., and designed in such a manner that connections can be made and maintenance carried out in safety on any piece of equipment without disturbance to another energised functional unit. Separate Glanding boxes will be provided. Ensure design of cubicles allows access to controls for maintenance purposes, without exposing live electrical terminals and connections. Removal of any covers to facilitate individual cabling of outgoing circuits, will not expose live parts.

- 45.2.5 The degree of protection between compartments shall be IP4X
- 45.2.6 Full segregation to be provided between low voltages and extra low voltages (as defined in IEE wiring regulations) and in particular between mains voltages, control voltages and equipment. Terminals above 50V will have clear covers marked with the terminal voltage.

45.3 IEC 1641 Guide For Testing Under Conditions of Arcing Due to Internal Fault

- 45.3.1 Compartment doors/complete assembly to be constructed to withstand the expansion of gases due to short circuits and to ensure venting of such gases does not endanger personnel and adjacent compartments.
- 45.3.2 Panels to be complete with a 50mm high, minimum, removable metal plinth.
- 45.3.3 Panels to be readily extendible from both ends and include spare panels as detailed in particular project specification.
- 45.3.4 Restrict equipment mounted on doors to instruments, control switches, and switch operating handles.
- 45.3.5 Divide each section of main switchpanel, into compartments on modular basis, to ensure future alterations and/or additions of equipment within the switchpanel can be accomplished without difficulty (i.e. bolted removable divisions not welded).
- 45.3.6 The degree of protection to be selected for the envisaged environmental conditions and minimum IP54 for sealed compartments and IP42 for compartments requiring ventilation, unless otherwise stated on the enquiry.
- 45.3.7 Compartment Arrangements
- 45.3.8 The following separate compartments to be provided as a minimum:
- 45.3.9 - main incoming isolator.
 - 45.3.10 - incoming instrumentation.
 - 45.3.11 - circuitry for each motor starter.
 - 45.3.12 - circuitry for CPSU.
 - 45.3.13 - marshalling compartment (if applicable).
- 45.3.14 Each compartment to be fitted with a gasketed, hinged door. Each door to be lockable using a special tool i.e. triangular cam type lock. Support brackets to be fitted to doors, where this is necessary to prevent flexing.
- 45.3.15 Each compartment to be fitted with a removable back plate fitted with DIN rails for component mounting.
- 45.3.16 Each withdrawable tray is to be fully removable without the use of special tools/lifting equipment. Lockable shutters are to be provided to prevent access to the busbars on removal of the withdrawable tray.

- 45.3.17 Withdrawable trays and slides should be robust, maintenance free and fit for duty. Catches should be provided to prevent the withdrawable tray from being withdrawn accidentally, equally catches are to be provided to prevent the tray being withdrawn too far.
- 45.3.18 A mechanical interlocking device shall be installed on all withdrawable starters, to prevent the tray being withdrawn whilst the device is in the ON position. Locating pins are to be provided to guide the withdrawable tray into position. Outgoing power plug & socket connections are to be minimum thermal rating of 50A, Outgoing control plug & socket connections to be a minimum thermal rating of 20A.
- 45.3.19 A minimum of 20 outgoing ways are to be provided for control wiring from the withdrawable tray to field terminals.
- 45.3.20 Components should be mounted on suitable din rail where practical.
- 45.3.21 The steelwork to be designed such that, the centre of, operator controls and indications on motor starters are at least 300mm and not more than 2000mm above floor level.
- 45.3.22 Where applicable provide for marshalling facilities for all control and signal terminations. Such facilities may comprise either a single dedicated marshalling compartment or separate terminal arrangements at the top of each shipping section.

48.4 Spare and Empty Compartments

- 45.3.23 Where fully equipped spare compartments are listed in the Schedule, they are to be furnished with all the equipment necessary to provide a functional unit of the type specified.
- 45.3.24 Spare space suitable for future use, should be divided into compartments proportional to the overall MCC scheme.
- 45.3.25 Spare compartments should be equipped with all necessary furniture, cabling and components to eliminate the need for shutdowns. A blank door or cover should be used to protect empty compartments.

48.5 Busbars

- 45.3.26 All busbars both main and subsidiary to be manufactured from hard drawn high conductivity copper. The entire busbar system is to be rated to withstand the short circuit time current specified and be fully type tested by an approved body i.e. ASTA.
- 45.3.27 Provide neutral busbars of same rating as phase busbars.
- 45.3.28 The busbars to be enclosed in a separate earthed metal chamber, with the main busbar located at the top of the switchboard. All busbar joint surfaces to be tinned or plated and all joints bolted together. Busbar identification, i.e. colour bands, to be provided at regular visible positions.
- 45.3.29 Consideration to be given to fully insulated busbar assemblies dependant on location/environment and integrity of supply requirements.
- 45.3.30 Ensure connections between busbars and all switchgear are adequately rated for load and fault current. All connections from the busbar system to protective device should be made in solid copper, where cable

connections are made the cable is to be kept as short as possible. Connection from busbar to protection device will require tests carried out to EN 60439-1: 1994

45.3.31 Ensure all penetrations of live busbars into outgoing circuit compartments or cable chambers are fully shrouded. Shroud and insulate all live parts, accessible or passing through various compartments.

48.6 Cabling

45.3.32 The small wiring to be single core 600/1000V grade LSOH insulated stranded copper conductor to BS 6231. Minimum cable sizes :-

45.3.33 - Power circuit - 1.5 mm²

45.3.34 - Control circuit - 1.0 mm²

Control Panel / MCC - Cable colours	
Mains voltage circuits (240 V / 415 V)	
Phase 1	Brown L1
Phase 2	Black L2
Phase 3	Grey L3
Neutral	Blue
Control Circuits:	
110Vac Live	Yellow/Brown
110Vac Neutral	Yellow/Blue
24Vac Live	White/Brown
24Vac Neutral	White/Blue
+48Vdc	Orange/Red
-48Vdc	Orange/Black
+ 24Vdc	White/Red
- 24Vdc	White/Black
CT wiring phase L1	Violet/Brown
CT wiring phase L2	Violet/Black
CT wiring phase L3	Violet/Grey
CT wiring neutral	Violet/Blue
Earth Conductors	Green/Yellow striped
I.S. Earth	Green/Blue striped

45.3.35 Fitted with interlocking numbered ferrules and is to be bunched and cleated or run in PVC trunking, in a neat and systematic manner.

45.3.36 Each wire to be clearly identified by a ferrule at each end, permanently numbered in accordance with the schematic control and wiring diagrams. The ferrules may be colour coded or have black numbers on a white background. Ferrules are to be used that completely encircle the conductor or a rigid supporting bar permanently attached to the conductor. Adhesive markers are not permitted.

45.3.37 Where applicable, wire numbers are to correlate with CU equipment numbering. Both compartment number and wire number to comprise two digits e.g. a typical wire number may be 07-21, for any wiring external to the compartment.

- 45.3.38 Wire numbers to be unique within the MCC.
- 45.3.39 Panel and associated drawings to contain a legend detailing wiring colour used and corresponding voltage level.
- 45.3.40 Bushes fitted where cable pass through metal partitions.
- 45.3.41 Auxiliary and control wiring is not to pass through the busbar chamber, without secondary protection.
- 45.3.42 Extra low voltage control wiring must be segregated from wiring at higher voltage.
- 45.3.43 Provide removable, gland plates on external surface of each switchpanel section, sized to suit the specified cables and bonded to main earth bar.
- 45.3.44 Where single core main cables are used the gland plates are to be of a nonferrous construction.
- 45.3.45 Provide unrestricted access to cable routes and terminations and facilities for firmly supporting cables within cubicle type switchboard, with cable sizes and types indicated for the particular project.
- 45.3.46 Ensure all cable compartments are sized to meet specification requirements and for full cabling/termination access.
- 45.3.47 Provide terminations suitable for copper cables. Fully rate neutral terminations as phase terminals. Fix, rigidly, all terminations.
- 45.3.48 All power, control and signal wires to be terminated using compression type crimps.
- 45.3.49 Terminals for power wiring to be of the clamp or stud type. Terminals for control wiring to be of the pressure clamp type or screw type. Pinch screw terminals, where the screw bears directly onto the conductor, are not permitted.
- 45.3.50 All wiring to be connected to the same side of an outgoing terminal block, the other side is only to be used for external wiring. Not more than one wire shall be connected to each terminal. Proprietary type cross-connecting links are to be used where conductors are to be commoned together.
- 45.3.51 Use Klippon type SAK, or equal, for auxiliary circuit terminations. Physically separate terminals for extra low voltage from those for low voltage circuits.
- 45.3.52 Provide insulating shrouds over terminals, labelled to indicate voltage class, were appropriate.
- 45.3.53 Clearly number or identify all terminals.
- 45.3.54 Provide safety screens and warning labels to all terminals which may be live after switching OFF main incoming unit(s).
- 45.3.55 Use design and siting of fuse carriers to prevent accidental contact with 'live' metal whilst the fuse carrier is being inserted or withdrawn from the fuse base.
- 45.3.56 Ensure adequate shrouding of the fuse base contacts to prevent accidental contact with 'live' metal when the fuse carriers have been withdrawn.

48.7 Earthing

45.3.57 There is to be good earth continuity between all non-current carrying metal parts.

45.3.58 Supply each panel with a suitably sized earth bar installed throughout the full length of the panel. Size copper earth conductor in accordance with the relevant standards for the fault level, subject to a minimum of 25 x 3mm.

45.3.59 Bond all equipment which is not specially earthed to main earth conductor by means of earth tapes sized in accordance with the relevant standards. Provide bonding connections to each item of switchgear, and cable gland plates.

45.3.60 Any hinged doors and removal covers to be earthed by a separate flexible earth conductor.

45.3.61 The earth bar shall be drilled to accommodate all the protective conductors and the main incoming supply cable earth.

48.8 Labelling

45.3.62 Shall be as labelling for LV panels.

48.9 Circuits

45.3.63 All circuits, selector switches, indicating lights, push buttons, etc.

48.10 Warning

45.3.64 All covers doors and complete assembly to be provided with suitable labelling to comply with Health and Safety requirements, colour coded to suit.

48.11 Cubicle Door

45.3.65 Each compartment will have a reference number, positioned in one corner of the door, on the outside. The reference number will be in two parts with a letter to designate the relevant column followed by a number to designate the position of the compartment in the column starting at the top. i.e. compartment B3 would be the third compartment from the top of the second column starting from the left.

45.4 Main

45.4.1 A main label in accordance with design standards. Detailing as a minimum the manufactures name and serial number, year of manufacture, voltage rating, busbar current rating, Fault Level, IP rating and switchboard references.

48.13 Other Supply Sources



- 45.4.2 Ensure where supplies in cubicles may be live from other sources than the main Motor Control Centre supply, a permanent label is fixed to the cubicle and to an internal polycarbonate barrier stating “CAUTION LIVE ELECTRICAL CONNECTIONS - TO ISOLATE REMOVE THE FOLLOWING FUSES etc.” Issue full label schedule for agreement prior to manufacture.

48.14 Switching Devices

48.15 General

- 45.4.3 Ensure short circuit ratings, current ratings, number of poles and fusing arrangements etc. are as indicated on the particular project drawings or in the specification.
- 45.4.4 Ensure that neutral connection/link of each device etc., is contained within its respective enclosure/moulding.
- 45.4.5 Ensure that all switching devices are suitable for padlocking in the 'OFF' position using a CU padlock. The switch cover or door to be interlocked with operating mechanism such that it cannot be opened with the switch in the 'ON' position, or the locked 'OFF' position.
- 45.4.6 Use switches of manual independent type not allowing switch to be closed unintentionally e.g. when changing fuses.
- 45.4.7 Provide positive drive ON/OFF indicators, and ensure ON and OFF positions of switch operating handles are arranged in a manner in which handles when operated, are identical for all fuse switches and switches on panel.-
- 45.4.8 Rate switches for uninterrupted duty, fault making and load breaking capacity without damage or reduction in service capacity thereafter.
- 45.4.9 Rate fully all neutral terminals to match phases.
- 45.4.10 Shroud all live cable terminals and fixed contacts with insulating material to prevent accidental contact with live metal when the switch cover is opened.
- 45.4.11 Provide for making off the incoming cable directly at either the top or at the bottom of the isolator. Fully shield termination points to avoid accidental contact, and label shield to indicate danger.

48.16 Circuit Breakers

- 45.4.12 Circuit breakers to be either 'Air Circuit Breakers' or 'Moulded Case Circuit Breakers' as specified. Fault rated to a minimum level equivalent to that of the busbar system. All primary breakers to be totally type tested with the secondary busbar system. Overloads shall be a minimum Micrologic 2.2.
- 45.4.13 The closing mechanism to be 'manual spring' unless otherwise stated on the enquiry.
- 45.4.14 ACB's to be withdrawable type.



45.4.15 MCCB's to be fixed, plug-in or withdrawable. Suitable for the functions of isolation and switching; marked with the disconnecter symbol accordingly. They are to utilise a trip free mechanism and capable of on site adaptation of auxiliaries and protective elements.

45.4.16 MCCB's shall incorporate Micrologic protection.

48.17 Fuse - Switch - Disconnecter and Switch Disconnectors

45.4.17 Fuse switch equipment to be of the fault making, load breaking type. Fault rated to a minimum level equivalent to that of the busbar system and be fitted with HRC fuses to BS 88.

45.4.18 Switch suitable for utilisation category AC23.

45.4.19 Motor starter fuse-switches to have test facility built into handle mechanism, test position to be clearly marked on handle.

45.4.20 Withdrawable starters are to use fuse-switches with test facility, the OFF position must be between the ON and TEST position, When in test position the starter must remain in the MCC with the door in the normal closed position, the fuseswitch can remain plugged onto the busbar system providing the main poles break in the test position.

45.4.21 Motor starter and CPSU fuse-switch-disconnector to be suitably rated, but not less than 32A. Operating shafts to be metallic.

48.18 Contactors

45.4.22 All contactors are to be comply with IEC requirements.

48.19 Protection and Metering Requirements

45.4.23 The specific requirements for protection and metering to be stated in the enquiry.

48.20 Motor Starters

48.21 Starter Isolators

45.4.24 Each starter will be complete with an isolator, to the standards laid down previously.

45.5 Control

45.5.1 All starters to be of the withdrawable pattern unless otherwise stated in the enquiry document, complying with the requirements of the relevant Design Standards.

45.5.2 Control options must be specified in the enquiry document.

48.23 Direct-on-line Starters

- 45.5.3 Direct-on-line motor starters to be designed and manufactured in accordance with the standard drawing.
- 45.5.4 Type 2 co-ordination must be provided unless agreed in writing by City University Operations Department.

45.6 Inverter Drives

- 45.6.1 Inverter drives to be based on the standard drawing and include all items contained therein, but modified as necessary to accommodate the different type of starter.
- 45.6.2 In auto mode, speed to be controlled via a remote 4-20mA control signal.
- 45.6.3 In hand mode, speed to be controlled via the manual speed control facility provided on the inverter unit.
- 45.6.4 A panel mounted keypad or perspex viewing window to be provided to view status indications on the inverter drive. The window to be designed to open, to allow adjustment of speed in the hand mode and for diagnostic access.
- 45.6.5 Inverter drives shall be manufactured by Danfoss.

48.25 Soft Start Drives

- 45.6.6 Soft start drives to be based on the standard drawing and include all items contained therein, but modified as necessary to accommodate the different type of starter.
- 45.6.7 Soft start drives to comprise an electronic assisted start system which will limit the motor starting current to between 100% and 400% (adjustable) of the motor full load current whilst allowing the motor to produce sufficient torque to accelerate the driven equipment.

45.7 Protection and Co-ordination

- 45.7.1 Overload relays to be of the hand/auto reset type, capable of being reset externally from the front of the compartment. Reset to be 'push-rod' type or electrical.
- 45.7.2 Overload relays to be adjustable over a range of setting currents and capable of being set at 115% of motor full load current.
- 45.7.3 Type '2' (all tests) co-ordination to be provided for each motor starter combination so that no damage is suffered by the components following a fault in an outgoing circuit.

45.8 Door Mounted Components (when specified)

- 45.8.1 Pushbuttons to be identified as follows:-
- 45.8.2 Start – Green



45.8.3 Stop – Red

45.8.4 Overload reset – black

45.8.5 Indication lamps to be high intensity LED type. Tripped lamps to be amber.

45.8.6 All panels to be equipped with lamp test switch which illuminates all lamps or LED's.

45.8.7 Three position 'Hand off Auto' switch with key.

45.8.8 An ammeter, 72mm square pattern to read full load motor current at approximately three quarter scale. The upper portion of the scale shall provide indication of the motor starting current. Ammeter to operate from a suitable current transformer.

45.9 Control Power Supply Unit

45.10 Transformers

45.10.1 Ensure control transformers are generously rated and sized to accommodate known requirements and extensions to MCC.

45.10.2 Provide transformers up to and including 3000VA as single phase with a 400V primary and suitably rated secondary to give 110V AC.

45.11 Transformer Secondary

45.11.1 - Suitably rated fuse to protect the transformer in live line.

45.11.2 - Suitably rated link in neutral line. Grounded to Earth.

45.12 Control Instruments

45.12.1 Mount 0-150V AC voltmeter, with a red line at 110V, on the door of the control section. Separately fuse voltmeter with Klippon type fuses in the terminal block.

45.13 Distribution

45.13.1 Provide a fuse link to feed each column, suitably rated to prevent nuisance tripping.



BUILDING SERVICES

49 SECURITY SYSTEMS

45.14 General

- 45.14.1 Provide a security system fully compatible with existing site systems and using the appointed security system specialist supplier/manufacturer.
- 45.14.2 Install the security systems wiring within dedicated and continuous cable containment systems comprising steel cable tray, trunkings and conduits, all concealed within building finishes. Terminate cable containment systems directly to equipment outlet boxes. Provide full and detailed information to enable the cabling installation of correct capacity and routing. Install cabling in accordance with the security system specialist supplier/manufacturer's specification and recommendations.
- 45.14.3 Issue to City University Operations Department for comment prior to manufacture, installation drawings of external housings and brackets, control units, monitors and brackets, intercoms, door contacts, magnetic locks, PIR's card readers and mounting boxes, power supply units, etc.
- 45.14.4 Provide all associated wiring diagrams for the security system.
- 45.14.5 Provide the project(s) with security systems protecting internal spaces from intruders, and controlling access into the building via certain doors, in accordance with the particular project requirements.
- 45.14.6 Install systems in accordance with the all relevant Standards and fully compatible with site systems.
- 45.14.7 Provide testing/commissioning, training and maintenance in accordance with City University Operations Department specific requirements.
- 45.14.8 Ensure security systems are not connected to the SCADA systems.
- 45.14.9 The security system will generally consist of the following, where indicated for the particular project:-
- 45.14.10 - Intruder alarm system.
 - 45.14.11 - Closed circuit TV (CCTV) system.
 - 45.14.12 - Card access system.
 - 45.14.13 - Panic system.
 - 45.14.14 - Door access control systems.
 - 45.14.15 - Intercom system.
 - 45.14.16 - Provisions for external security systems by others.



- 45.14.17 Ensure external security cables are run in dedicated pipe ducts and draw pits to pick up the existing site infrastructure. Lids to drawpits will not be monitored.

- 45.14.18 Provide all power supplies, including local 240V unswitched fuse connection units, where applicable, for all security systems.



50 DATA COMMUNICATIONS

Reserved for future use.



51 VOICE COMMUNICATIONS

Reserved for future use



52 BUILDING MANAGEMENT SYSTEMS

See City University Operations Department Standard



IDENTIFICATION OF ELECTRICAL SYSTEMS

53 IDENTIFICATION OF ELECTRICAL SYSTEMS

45.16 Labelling

- 45.16.1 Provide to all control equipment, including switchboards, motor control centres/cubicles, control panels, starters, distribution boards, labels suitably engraved with indelible characters (not less than 6mm high Arial), indicating the purpose and/or use of the equipment.
- 45.16.2 Engrave all labels using 'Traffolyte' white with black lettering except for warning notices which shall be white with red letters, all fixed with chrome round headed screws.
- 45.16.3 Provide to all distribution boards, circuit charts enclosed in clear perspex or a substantial plastic envelope, firmly fixed to the inside front cover by a permanent adhesive.
- 45.16.4 Include the following information on all circuit charts:-
 - 45.16.5 - Description of each circuit against the respective circuit number.
 - 45.16.6 - The rating and type of each protective device(s).
 - 45.16.7 - The size of the sub-main and final circuit cable, and circuit protective conductor.
 - 45.16.8 - The phase to which the circuit is connected.
 - 45.16.9 - Spare ways shall be left blank.
- 45.16.10 Type all circuit charts and clearly relate to the ways in the distribution board in the approved City University Format.
- 45.16.11 Where protective devices include combined residual current devices or multiple devices, ensure circuit charts clearly identify the above information and equipment arrangement in each distribution board.
- 45.16.12 Designate switch panels, distribution boards and similar distribution units, unless indicated otherwise, in accordance with the reference letters or numbers advised by City University Operations Department.
- 45.16.13 Clearly and permanently mark all busbars by sleeving or similar in the phase colours brown / red, black / yellow, grey / blue, and blue / black for the neutral, on AC systems.
- 45.16.14 Identify particular phase connections to fuse banks and busbars by marking with the appropriate colour by sleeving or similar.
- 45.16.15 Provide 'Danger - 400 VOLTS' labels in accordance with the above, to all control equipment, and distribution boards, where applicable.
- 45.16.16 Include for identification of conduits in compliance with the relevant Standards.

- 45.16.17 Provide labels on every accessory (e.g. light switches, socket outlets, fuse connection units etc.) detailing the full final circuit reference.
- 45.16.18 Submit copies of labels and distribution board schedules for comment by City University Operations Department prior to manufacturing and fixing.
- 45.16.19 Identify loose switchgear such as fused switches, switch fuses, isolators, indicating switches, starters and control switches controlling remote equipment, by an externally fitted label or engraving, indicating the equipment controlled.
- 45.16.20 Identify each junction box by an externally fitted approved label, indicating the type of service contained, such as fire alarm, telecommunications, security etc.
- 45.16.21 Label all 'accessory boxes' internally with their circuit reference.
- 45.16.22 Ensure safety signs are of the types defined and in conformity with the requirements of the relevant Standards.
- 45.16.23 Provide all statutory notices required with regard to electrical installations in a proprietary substantial and permanent form, in addition to notices required by the relevant Standards.
- 45.16.24 In all switchroom and/or sub-stations provide and fix in a conspicuous place all notices in accordance with this Specification.

45.17 City University Standards

- 45.17.1 Determine with City University Operations Department, prior to commencement of design or installation, all current labelling and identification requirements for standard and/or particular project requirements.
- 45.17.2 Include for the following principles of system and installation identification requirements which incorporates the BS 7671 wiring colour changes introduced in 2004.

Existing	New	Explanation
		Building Reference - Identification at main sub-station or incoming supply/isolator position to building.
		LV switchpanel/distribution equipment connected to way No. 1 of sub-station LV secondary distribution equipment.
		Way No. 2 connection from LV switchpanel/distribution equipment, and corresponding phase(s) connected.

		Way No. 3L1 final circuit connection from distribution board fed from way No. 2 of LV switchpanel (also applies to labelling to accessories connected to circuit).
Existing	New	Explanation
		Distribution board which is fed from the brown / red phase of way no.2 of board B200/1
		Way no.1 of distribution board which is fed from the red phase of way no.2 of board B200/1. At first glance the reference seems to be B200/1/2L1/1 by replacing the R with L1 but board B200/1/2L1 does not exist so we must retain the R in the identification.

45.17.3 To minimise the potential for errors City University Operations Department has adopted the following;

45.17.4 - All neutrals will be marked with a capital N plus the way number, e.g. N1, N2.

45.17.5 - Single phase neutrals will be marked N1L1, N1L2, N1L3 etc.

45.17.6 - All earths will be marked with a capital E plus the way number similarly to neutrals e.g. E1, E2 and E1L1, E1L2, E1L3 etc.

45.18 Shock Treatment Card

45.18.1 Provide a current Shock Treatment Card in each substation, HV and LV switchroom and at each separate main switch panel or distribution board cupboard/room position. Ensure the card gives the following information:-

45.18.2 Instructions for isolating a person from live conductors.

45.18.3 Artificial respiration and resuscitation methods.

45.18.4 Location of nearest telephone and telephone number of whom to contact for assistance.



TESTING, COMMISSIONING AND RECORDS

54 TESTING, COMMISSIONING AND RECORDS

- 45.18.5 Inspect and test the complete installation to ensure it complies with the requirements of this Specification and all relevant Standards.
- 45.18.6 Carry out inspection, testing, commissioning and issue certificates and test schedules prior to handover. Concealed or buried work shall be inspected and tested before any permanent covering is applied.
- 45.18.7 Carry out the inspection and tests in the same sequence as set out in the relevant standards, and in such time to allow any remedial work to be completed within the Contract Period. Ensure tests also include any part of an existing installation related to the new work.
- 45.18.8 Submit a detailed programme of testing to City University Operations Department at least seven days prior to the commencement of the tests. Notify Manufacturers or specialists where necessary. Indicate in programme the sequence and timing of inspection, testing and commissioning requirements. Provide check list to record of all tests, measured readings and adjustment settings.
- 45.18.9 Supply all test instruments required to satisfactorily carry out all tests. Ensure they are calibrated immediately prior to commencement of testing and operated by trained personnel. Prior to commencement of tests ensure City University Operations Department is asked to comment on the suitability of the proposed test equipment and methods of testing being adopted. Provide all materials and consumables required to carry out inspection, testing and commissioning.
- 45.18.10 Allow for disconnection or similar operations to satisfy the requirements for testing, etc., and the reinstatement of the installation.
- 45.18.11 Carry out all testing, inspection and commissioning to specialist installations as defined in the relevant section of the Specification and the relevant Standards.
- 45.18.12 Include commissioning of the installation in fully functional order as intended by the Specification. Include proving all interlocks, switches, controls, etc. and the following requirements:-

45.19 Switchgear

- 45.19.1 Demonstrate operation and safety procedures for all switchgear, including any Castell keys or other means of mechanical interlocks. Adjust protection settings as specified. Check circuit breakers protection settings by primary injection testing and secondary injection testing, where applicable.

45.20 Transformers

- 45.20.1 Select primary tapplings to give as near as possible 400/230volts on normal running load of the installation at the incoming LV switchboard.

45.21 Plant Installation

45.21.1 Set to work and demonstrate the completed works to verify that:-

45.21.2 - Equipment provided complies with the Specification in all respects and is of adequate capacity for its full rated duty.

45.21.3 - Individual items and composite systems operate as specified and within any limits of noise, exhaust, vibration, etc. specified.

45.21.4 - Emergency stops and safety features operate correctly and in a 'fail safe' mode.

45.21.5 - Adjustable items for protection and control are correctly set.

45.22 Test Schedules and Certificates

45.22.1 Record all details, measurements and data as required in the relevant Standards and provide two copies of the Completion and Inspection Certificates together with any supportive documentation required in the relevant Standards, to City University Operations Department within seven days of the tests being carried out.

45.22.2 Provide a detailed schedule of the visual inspections, in accordance with the relevant Standards.

45.22.3 Provide test certificates of all equipment and components forming part of the electrical works including:-

45.22.4 - Cable works test certificates for HV and LV systems.

45.22.5 - Site built assemblies.

45.22.6 - HV equipment, switchgear and accessories where appropriate.

45.22.7 - LV equipment, switchgear and cubicles.

45.22.8 Include in the Operating and Maintenance Manuals, copies of all inspections, test and commissioning schedules and certificates.

45.22.9 Test schedules and certificates shall indicate all test instrument details including:-

45.22.10 Manufacture, type, date of calibration, scale of tests completed, recorded results/tolerances.

45.23 Spares/Tools, Instruction Manuals Etc.

- 45.23.1 Provide fully itemised schedule of spares for each and every system and item of equipment installed under the electrical works, as detailed in the Specification and on the particular project drawings.
- 45.23.2 Price each item of equipment on the spares schedule. Provide costs of spares in total, together with the schedule for consideration by City University Operations Department, noting that they reserve the right as to whether or not the provision of spares under this section forms part of the Contract works.
- 45.23.3 Identify on the schedule of spares, those items forming part of normal spares to be provided for each particular project to ensure standard duty and operation/maintenance of the electrical plant and/or equipment.
- 45.23.4 It is a requirement that the collection of the relevant collated information and schedules of spares is carried out at the time of tender, from each supplier of the contract works.

45.24 Instruction Manuals

- 45.24.1 Provide operating and maintenance instruction manuals for all items forming the electrical works.
- 45.24.2 Issue for approval, a draft copy of the instruction manuals contained in a temporary loose leaf binder. Issue 8 weeks prior to completion of a Section, for comments by City University Operations Department.
- 45.24.3 Handover two copies of the final documents at least one week prior to Completion, or Completion of a Section of Electrical Works. Include all testing and commissioning results, and final equipment duties and control settings etc., in a typed form.
- 45.24.4 Cover all items of plant and equipment. Include detailed physical and functional description of the complete installation, supplemented with manufacturer's details and maintenance instructions for all components, plant and equipment and all diagrams and data required for the successful operation and maintenance of the plant and equipment.
- 45.24.5 Ensure manuals conform to the following minimum standards:-
- 45.24.6 Multi-ring PVC bound stiff binder able to withstand constant usage, or where a thicker type of binder is required, it shall have steel locking pins.
- 45.24.7 Divide section of the manual by a stiff divider of the same size as the holder. Then label the divider with the section of the manual which is following.
- 45.24.8 Ensure all written instructions within the manual are typewritten with a margin on the left hand side.
- 45.24.9 Ensure all information contained within manuals is legible and professionally produced, and comprises the following information and is complete in all respects:-

- 45.24.10 - Full instructions from manufacturers on the operation and maintenance of equipment supplied under the contract.
- 45.24.11 - Information on any special tools that may be required for services.
- 45.24.12 - Description of emergency action to be taken in the event of equipment failure, including a list of servicing agents, manufacturers' names, addresses and telephone and fax numbers.
- 45.24.13 - A schedule of ordering codes for all equipment installed, including manufacturers' reference numbers and name plate data where applicable.
- 45.24.14 - A full set of record drawings, including schematics and diagrams for the complete installation, as listed above.
- 45.24.15 - A list of manufacturer's recommended spare as for each item.
- 45.24.16 - Where the Operation and Maintenance Manuals consist of several volumes provide a complete master index within each of the volumes which forms the overall set.
- 45.24.17 - Only include data associated with installed systems. Only include originals of catalogues etc. Photocopies are not acceptable. Ensure manufacturers' literature is of current issue at the date of handover.
- 45.24.18 - Provide a consistent form of page numbering.
- 45.24.19 - Include full sets of test certificates/records, along with copies of any maintenance agreements.
- 45.24.20 Bind the manuals with a cover which clearly states the contract title and site identification. Make these covers consistent for all volumes of manuals forming part of a set.
- 45.24.21 Ensure all manuals along with relevant record drawings are A4 in format. If the record drawings are larger than A4 fold neatly and contain within individual A4 clear plastic wallets within the associated manuals.
- 45.24.22 Provide a full schedule of all installed plant with locations, maintenance requirements and maintenance frequencies in a format acceptable to City University Operations Department.

45.25 Working Drawings, Record And As-Fitted Drawings, Approvals

- 45.25.1 Provide the following drawings:-
 - 45.25.2 - Installation/Working drawings.
 - 45.25.3 - Builders work drawings.
 - 45.25.4 - Plant and Equipment drawings.
 - 45.25.5 - Record drawings.

- 45.25.6 Drawings shall be to the International 'A' series, as referred to in the relevant Standards.
- 45.25.7 Ensure all symbols are generally in accordance with the relevant Standards and shall be approved by City University Operations Department prior to preparation of any drawings.
- 45.25.8 Include in every drawing the name of the Contract as shown on the cover of the Specification for each particular project.
- 45.25.9 Cross referenced drawings for ease of interpretation.
- 45.25.10 Produce and present all drawings on a CAD format agreed with City University Operations Department, based on the latest Autocad Series, with files in DXF and DWG formats.
- 45.25.11 Electrical design schematics must be suitable for use with the 'AMTECH' suite of electrical design software.
- 45.25.12 Ensure the production of co-ordinated composite installation/working and coordinated composite builder's work drawings include all engineering services information.

45.26 **Installation/Working Drawings**

- 45.26.1 Ensure no installation proceeds without suitably produced and commented drawing or without detailed information of the other sub-contract works, Structure or Architectural details and information.
- 45.26.2 Indicate all elements of Structure, Architectural form and Engineering Systems on composite installation/working drawings.
- 45.26.3 Incorporate installation/working details on CAD using independent layers displayed 'on screen' in different colours.
- 45.26.4 Base installation/working drawings on the latest issue of the Architectural and Structural drawings and any other drawings or information on trades or disciplines issued for the particular project. Ensure drawings show the specified or selected plant and equipment in true proposed locations.
- 45.26.5 Provide copies of manufacturer's certified drawings for major items of plant, indicating physical dimensions, schematic arrangements for components and full detailed electrical wiring diagrams.
- 45.26.6 Ensure the installation/working drawings show all plant, equipment and cable/conduit/pipe/duct runs etc. Include on the drawings full details of all plant together with system and equipment sizes, wiring drawings, schematic and interconnection diagrams/drawings.
- 45.26.7 Commence no work until the relevant installation/working drawings have been commented upon by City University Operations Department and issued.
- 45.26.8 Ensure composite circuit and layout diagrams for the electrical wiring of plant etc., indicate all circuitry within main control panels, but also that within all external equipment, such as starters, thermostatic control devices, together with all interconnecting wiring from the main

point of supply onwards and all terminal markings. Indicate sizes and types of all cables on the layout diagrams together with the ratings of such items as fuses, switches and control.

- 45.26.9 Arrange circuit diagrams so that the main sequence of events is from left to right and from top to bottom of the diagram. Symbols for diagrams shall comply generally with the relevant Standards. If abbreviations are employed for the designation of components, an integral schedule shall be provided on the drawings to explain the meaning of the abbreviations.
- 45.26.10 Include the composite diagrams as part of the set of "As Fitted" drawings.
- 45.26.11 Provide individual circuit and layout drawings from the various component manufacturers in addition to composite diagrams.
- 45.26.12 Where revisions take place to the electrical works, modify drawings accordingly and re-issue for construction purposes any such modified drawings.
- 45.26.13 Specific installation drawings may, by the prior agreement of City University Operations Department, omit minor details, such as conduit, provided that a method statement rigorously covers the installation intent.
- 45.26.14 Include on the installation and working drawings details of all local co-ordination around equipment, control panels, individual plant at access points and on architecturally finished surfaces. Ensure all panel door swings are indicated.
- 45.26.15 Show sufficient detail to enable the erection and installation of the works in accordance with the Specification. Show sufficient clearances for dismantling, maintenance, insertion of equipment, painting, cleaning and commissioning.
- 45.26.16 Indicate possible causes of obstruction or restriction, either structural or by other services, to enable alternative routes to be considered. Ensure electrical equipment and control items are shown on all relevant drawings including coordination and incorporation on mechanical drawings.

45.27 **Builder Works Drawings**

- 45.27.1 Produce installation/working drawings as detailed in the Specification. Detail installation/working drawings around all builders work information and details.
- 45.27.2 Prepare all necessary builders work drawings required for the execution of the electrical works, making reference to the Structural and Architectural final dimensioned detail drawings as applicable. Ensure drawings are fully dimensioned.
- 45.27.3 Mark on site actual locations of all builder's work holes through walls, partitions, floors, etc., and also chases in walls, floors, etc., for conduits, etc.
- 45.27.4 Provide all builders work drawings in sufficient time to comply with the particular project and agreed programme requirements.

45.28 **Record Drawings and As-Fitted Drawings**

- 45.28.1 Provide record drawings of the complete electrical installation on Completion, or Completion of Sections of the works.
- 45.28.2 Produce record drawings on common building outlines and structural details.
- 45.28.3 Ensure the system for production of drawings is the Autocad system (latest revision).
- 45.28.4 Incorporate the required information onto drawings and also produce agreed computer disk copies for use by City University Operations Department.
- 45.28.5 Ensure the information contained on the final drawings is provided such that independent 'layers' are created with selected categories of information on each layer. Agree the selection with City University Operations Department prior to creation of the CAD drawing files.
- 45.28.6 Issue record drawings of the final "as installed" layouts in draft form for comment by City University Operations Department prior to the testing and commissioning period to allow checking for accuracy. Revise the completed sets of draft record drawings, as necessary, to incorporate testing and commissioning data where applicable. Handover the final set(s) of record drawings in accordance with particular project requirements and programme.
- 45.28.7 Issue the complete approved package of record drawings made up of 1 set of DVD or CD Rom disk and 2 sets of white paper prints.
- 45.28.8 Maintain on site, a set of drawings for the purpose of progressive marking up of alterations and variations. Ensure these drawings form the basis for the record drawings, shall be available for inspection by City University Operations Department at any time.
- 45.28.9 Provide a set of draft marked up white paper prints, issued 8 weeks prior to Completion of a Section of the works, for comment by City University Operations Department.
- 45.28.10 Indicate on the "Record" drawings the completed works As Installed. Show all plant, equipment and cable/conduit routes, together with full details of plant/cable sizes etc. and schematic diagrams as appropriate and indicate all electrical equipment positions, routes, sizes, types, trunkings, cable trays/ladder, cables, conductor joints/boxes, main/sub-main cable routes above and below ground. Also identify circuiting, distribution board arrangements including all switchgear, and identification and labelling.
- 45.28.11 Ensure the "Record" drawings show any other information, even if previously shown on working drawings, which may be useful in the operation, maintenance, of subsequent modification or extension to the electrical installation. Show reference numbers or letters, for the electrical items or any parts thereof, corresponding to the lettering, numbering or any identification fixed to plant or equipment.
- 45.28.12 Ensure the final drawings also conform to the following standards:-
 - 45.28.13 - Hard copy drawings on best quality transparent acetate film.
 - 45.28.14 - Ensure each drawing indicates the following information:-
 - 45.28.15 - City University Operations Department full title and address.

- 45.28.16 - Name of Contract and, where appropriate, the building, site, zone and floor designation, plant location etc.
- 45.28.17 - Description of drawing number and scale.
- 45.28.18 - Name and address of Originator/Installer.
- 45.28.19 Sign completed drawings as true 'Record' drawings and submit at the same time as Operating and Maintenance Instruction Manuals for comment by City University Operations Department.
- 45.28.20 Note that in the event of non-compliance with the requirements for production of any drawings, City University Operations Department reserve the right to have separately prepared the necessary drawings and to deduct the cost of preparing same from the monies due to the Installer in accordance particular project contract.

45.29 Approvals

- 45.29.1 Provide samples and drawings, technical details/data, manufacturers literature etc. for appraisal by City University Operations Department for all specified/selected items which form part of the electrical works both for exposed visible and concealed sections of the works. Ensure all details required by City University Operations Department are made available at their offices or at another point agreed by City University Operations Department .
- 45.29.2 Ensure samples and all other information and details etc. are provided for the following but shall not be limited to:-
 - 45.29.3 - Finishes to electrical equipment and accessories.
 - 45.29.4 - Room mounted control equipment.
 - 45.29.5 - Luminaires, diffusers etc.
 - 45.29.6 - Trunking/containment systems.
 - 45.29.7 - Special cable types.
 - 45.29.8 - Fire alarm equipment.
 - 45.29.9 - Security equipment.
- 45.29.10 - Other electrical equipment defined in the Specification or for the particular project drawings.
- 45.29.11 - Wiring accessories/switches.
- 45.29.12 - All labelling.
- 45.29.13 - Typical record drawings and schematics.
- 45.29.14 Where approvals are required for major items of electrical plant and equipment e.g. switchgear, transformers, generators, UPS systems, control panels, motor control centres, distribution equipment etc., provide for arranging works visits by City University Operations Department, to view typical and/or selected manufacturers equipment. Arrange such visits



prior to placing of orders, and provide all relevant drawings, technical details prior to such visits to enable full assessment of the equipment or options to be made by City University Operations Department. Arrange for visits, to meetings arranged with City University Operations Department, by all proposed or specified manufacturers technical representatives.

45.30 Witness Tests

- 45.30.1 Where witnessing is arranged, carry out prior tests to ensure that the witnessed testing and commissioning is not prolonged by fault finding and rectification. Faults or unsatisfactory operations that result in abortive witness tests shall be rectified at the expense of the Installer and any expense incurred by City University Operations Department as a result of abortive tests shall be chargeable.
- 45.30.2 Carry out the following procedures:-
- 45.30.3 - Detailed inspection and testing, in accordance with the relevant Standards .
 - 45.30.4 - Ensure that any equipment physically damaged, whether the safety is impaired or not, is replaced free of charge.
 - 45.30.5 - Check all accessories, equipment, control circuits, systems, RCD's etc., and demonstrate for proper functioning.
 - 45.30.6 - Prove circuit identity of protective device, including neutrals.
 - 45.30.7 - Verify cable end markings and colours are correct.
 - 45.30.8 - Carry out an extra low voltage continuity test to ensure a safe measure of earth bonding before the earth fault loop impedance tests are made.
 - 45.30.9 - Phase rotation of three phase supplies throughout the installation. Ensure that cable core colour coding or numbering is consistent and that all three phase socket outlets have the same phase rotation.
 - 45.30.10 - Test the earth fault loop impedance and prospective short circuit fault current on each point on the installation, switch and fuse gear and exposed metalwork bonded to earth where applicable. Ensure tests are phase/earth for all installations and that each main, submain and final circuit distribution board fault current measurements are taken from phase to phase, phase to neutral and phase to earth using approved test equipment. Where RCD's are connected to circuits, disconnect prior to the tests, where applicable.

45.31 Works Tests

- 45.31.1 Arrange for all major items of equipment, including:-
- 45.31.2 - High Medium voltage switchgear.
 - 45.31.3 - Transformers.

45.31.4 - LV switchgear and switchpanels.

45.31.5 - Power factor correction cubicles.

45.31.6 - Motor control centres and panels.

45.31.7 - Control panels.

45.31.8 - Emergency lighting control battery cubicles.

45.31.9 - Uninterruptable power supplies (UPS).

45.31.10 - Standby generators.

45.31.11 All equipment shall be fully works tested, prior to arrival on site, to ensure compliance with design standards, specification, functional and operational requirements, drawing details and layouts, installation arrangements and details. Provide for City University Operations Department to attend and witness works tests to all equipment appropriate for each project. Attendance at works tests to be at discretion of City University Operations Department.

45.31.12 Ensure manufacturers/specialists own works tests are carried out prior to works witness tests being arranged, and that satisfactory testing, inspection and commissioning certificates and schedules are issued to City University Operations Department.

45.32 **Acceptance**

45.32.1 Following satisfactory completion of all site tests, works tests, inspections and commissioning activities and setting to work of the electrical works, submit all completed certificates, schedules, charts, results and related documents to City University Operations Department for comment and/or acceptance.

45.32.2 Acceptance or acknowledgement of any test results or data by City University Operations Department or their representative, will not obviate or relinquish the Installer of responsibility of the works, or any part of the same, as required in the Specification or relevant Standards, Regulations or Codes of Practice etc.

45.33 **Asset Register**

45.33.1 Provide a full list of all installed plant and equipment in a format supplied by City University Operations Department four weeks prior to completion. Asset or identification numbers will be allocated by City University Operations Department and all plant and equipment shall be identified accordingly by the Contractor. The Contractor shall also supply in an agreed format, full details of maintenance requirements in SFG 20 format for all plant and equipment.

45.34 **Maintenance Contracts**

- 45.34.1 Provide separate quotations for the maintenance of all equipment and systems, within the particular project scope of works, for a full 12 months period from the date of Completion or Completion of Sections of Works.
- 45.34.2 Carry out maintenance strictly in accordance with the various manufacturers recommendations and sufficient to ensure that the services operate at optimum efficiency and that life expectancy of the various items of equipment and system components are not compromised.
- 45.34.3 Include for manufacturers own appointed maintenance staff to carry out the works necessary, where Installers own maintenance staff are not employed.



Appendix 1 Electrical Safe Working

Contractor to ensure that they obtain a current copy.

Electrical Safe Working

The process outlined below must be followed methodically to allow new electrical works to be safely designed, installed, tested, energised and accepted into service. Failure to follow the process will result in delays and / or abortive works. No claims for additional costs or time caused by such a failure will be entertained by the University.

For new electrical installations or alterations to existing installations the entire process should be followed.

Works of a non electrical nature which require electrical isolations such as demolition or strip out should commence at (9) below

1. This process applies to new electrical installations, alterations or additions.

The designer or installer must produce:

A simple single line diagram of the proposed installation showing switchgear, distribution boards, points of isolation or protection and interconnecting cables which are to be installed.

Approximate locations must be advised.

Approximate EMD's (estimated maximum demand) must be provided.

A part completed asset register must be submitted.

2. The PAF Operations Team will review (1) above and subject to comments advise asset numbers to be used and points of supply.

3. The designer or installer should request CU resource to provide supply characteristics of the point(s) of supply.

4. The CU PM shall arrange a meeting between the Principal Contractor and PAF Operations to talk through this procedure. The Principal Contractor will be expected to sign a copy of the procedure to confirm it has been understood.

5. The designer or installer must produce:

Amtech format design calculations detailing the points of supply and characteristics from (3) to demonstrate the proposed installation is correctly selected and sized. The calculations must as a minimum include a reference sheet showing the source of short circuit and earth fault levels for each supply, a distribution board schedule, cable schedule, cable calculation report, protective device settings report, time current discrimination report and energy based discrimination report.

6. The project Consultant shall review the Amtech calculations and comment on their accuracy and completeness for acceptance by PAF Operations.

PAF Operations shall review the comments and calculations and accept or reject them if they are considered incomplete or inaccurate.

7. For a new installation, once Amtech documents have been accepted by PAF Operations the installation may proceed strictly in accordance with City University Specification.

For additions or alterations to an existing installation proceed to (8).

8. The electrical installation in the works area must be isolated to allow safe working whether by electrical or other trades.

Any requirement to maintain supplies to non works areas must be planned and agreed by PAF Operations prior to isolations being requested.



Appendix 2 Distribution Board Cupboards

Size of cupboard to suit equipment to be housed. All DB covers etc. must be removable without removing cupboard stiles or doors.

Materials

18 MM MDF

Lacquer Finish

PU ref 30GY88/14

Ironmongery

Handles - Hafele 151.44.634

Hinges – Hettich – 907.1205

Locks – 3 V Ironmongery

1 off of each required per DB enclosure

03.085.055.2030.SSS - 85mm Euro profile Mortice Deadlock with 85 mm backset

99.999.9CT.0194.SP7 – Best SCP 43mm Euro Single Cylinder Carcass

XX.ER.RI.PZ – 55mm diameter euro profile Cylinder rose modified for Best core

99.999.9CT.0573.DB18 – 457 SCP surface door bolt complete with 3 keeps (2 required per DB Enclosure)

Appendix 3 Typical Distribution Board Drawing

