Tel: 01793 533222

Fax: 01793 533215

APPENDIX E

ELECTRICAL SPECIFICATION

For: **Central Swindon North Parish Council**

Project: **John Moulton Hall Community Centre, Penhill Drive, Swindon SN2 5DU**

Affleck Group Services

10a Oppenheimer Centre

Greenbridge

Swindon

SN3 3LH

Ref: **1950/GM**

Date: **April 2018**

CONTENTS

DIVISION 01 INTRODUCTION

1 INTRODUCTION

1.1 The scope of the project is to provide an electrical services installation for the refurbishment works at John Moulton Hall Community Centre.

1.2 The scope is to include;

a. Mains distribution

b. Earthing and bonding

c. Luminaires and wiring

d. Power installation, outlets and wiring

e. Fire alarm installation

f. Data/telecom cabling and outlets

g. Security installation

h. Mechanical services wiring installation

j. Inspection and testing

1.3 The drawings for the scheme are as per the drawing schedule.

1.4 The exact programme and sequencing of the works will be agreed prior to the works commencing.

1.5 The Contractor shall prepare a detailed proposed programme and submit with the tender to show the works on site.

DIVISION 03 CONTRACTORS OBLIGATIONS

1 GENERAL/CONTRACTUAL

1.1 The Service Contractor shall supply, install, test and commission the complete building services as shown on the drawings and described in this specification, to the entire satisfaction of the Contract Administrator in the performance, aesthetics and general layout of the installation.

1.2 The specification and drawings shall apply throughout the project.

1.3 Alterations shall not be made to the detail of the specification or the drawings without written permission from the Contract Administrator.

1.4 Samples of materials shall be provided before installation commences, upon request, at no cost to the Employer.

1.5 For specific divisions following on after Division 03 and 04 the reference 'Contractor' shall be deemed to mean the relevant Contractor applicable for the works described.

2 BUILDING SERVICES CONTRACT REQUIREMENTS

2.1 Building Services Contract Progress:

a. The Contractor shall arrange the works to suit the progress of all trades and no charge will be met for any overtime necessary to comply with the agreed programme.

b. The Contractor shall prepare, after consultation with their suppliers, a programme clearly indicating the sequence of operations for the services contracts works and which shows the extent to which the required progress of the Contract is dependent on the operations of the Services supplies.

c. The Contractor will act as Co-ordinator in terms of co-ordinating, drawing information, production and installation co-ordination. The Building Services Contractor shall attend, on request, all site co-ordination meetings called by the Contract Administrator. The Contractor shall develop detailed design co-ordination proposals for their own scope of works and where applicable in relation to other trades. Through the co-ordination meetings the building services co-ordination shall be developed and signed off for formal issue on drawings for approval by the Contract Administrator. All Building Services Contractors are requested to note the above and compile their tender accordingly.

2.2 Building Services Contracts Responsibilities: In addition to the other requirements of the Contract, attention is drawn to the following additional requirements. The Contractor is responsible for fully allowing for these requirements in his tender and for efficiently carrying them out as part of the Works.

Building Services Contractor shall provide the following personnel. These shall be named in writing to the Contract Administrator.

a. Contracts Manager to be responsible overall for all co-ordination and resource programming, and the performance of the Contractor in carrying out the Works. The Contracts Manager shall be required, on request, to attend meetings called by the Contract Administrator.

b. Contracts Engineers to be responsible for all drawing work, programming, site control, co-ordination activities and attendance at meetings called by the Contract Administrator.

c. Foreman-in Charge.

2.3 Design Responsibility: The Building Services Contractor shall be responsible for the design elements involved in producing the working drawings from the Consultants Tender Drawings and Specification.

The Building Services Contractor shall be required to attend all meetings called by the Contract Administrator in the development of the installation/production drawings etc., detailed below and the planning of the works.

The Contract Administrator shall monitor the performance of the contractor in the production of:

a. the evolution of installation/production drawings etc., detailed below from the specification and tender drawings.

b. working drawings and co-ordination detail.

In respect of these matters the Contractor shall provide to the Contract Administrator copies of drawings as defined below. Furthermore, the Contractor shall provide to the Contract Administrator two copies of any additional supporting details requested, within 7 days of such a request.

2.4 Working Drawings:

a. It is of the essence of the contract that the Contractor shall provide a complete set of fully co-ordinated working drawings showing the detailed layout of all the services and equipment that is to be supplied and installed.

b. No installation shall take place before the Contract Administrator has been allowed 14 days to make his comments on the working drawings. Should comment by the Contract Administrator be required immediately to avoid delays, the Contractor shall bring this to the Contract Administrator's attention.

c. 2 copies of all working drawings shall be provided to the Contract Administrator after the detail shown has been agreed.

Failure to comply with this requirement shall render the Contractor liable for the whole cost of rectification and responsible for any damages arising from any delays that may occur.

Working drawings shall be to a schedule and at a scale to be agreed with the Contract Administrator. All builders work and critical dimensions for the co-ordination of the installation with other trades shall be shown. The material of which each part of the installation is to be made is to be shown on the drawings.

Tenderers shall submit with their tender bid a schedule of working drawings with the scale indicated of the drawings they anticipate will be required.

The following is a definition of the types of drawings that have been and are to be provided for the Works, together with a definition of who is to provide them.

The Contractor is asked to note that the tender drawings have been produced by the Services Consultant by Computer Aided Draughting [C.A.D.] methods. The Contractor must prepare all the drawings listed below, which are his responsibility, by the same method.

The Contractor is to allow for all necessary Hardware, Software, consumables and printing facilities, to provide the drawings listed below during the construction phase, to meet the programme.

a. Tender Drawings:

These drawings have been prepared by the Services Consultant in such detail as may be necessary to enable those tendering to interpret the design of the Works and to submit a competitive tender for their execution.

b. Production/Installation Drawings:

These drawings may be prepared off site.

These are drawings to be prepared by the Contractor and shall include such co-ordinated details, dimensional information plans and sections to enable the Works to be installed, including but not limited to:

General plans and sections of all parts of the Works.

Large scale plans and sections of all plant room layouts.

Large scale sections through ceiling voids, service ducts etc., showing the arrangement of the Works.

Plans and elevations of positions and sizes for surface trunking and conduits, together with dimensions for positions and sizes of thermostats switches and control gear located on walls.

Diagrammatic details of distribution boards and controls arrangements.

The Production/Installation drawings shall be based on the following information.

Tender drawings and any subsequent amendments made to the tender drawings by the Contractor, during the course of the Contract.

The drawings provided by other suppliers and Contractors and any subsequent amendments made during the course of the Contract.

c. Manufacturers/Suppliers Drawings:

These drawings may be prepared off site.

These are drawings prepared by manufacturers and suppliers under the instructions and directions of the Contractor. The Contractor remains responsible for their completeness and accuracy. These drawings shall include but not be limited to:

Manufacturers descriptive literature and technical details.

Details of plant and equipment to enable weights, support details, holes in structure and final electrical details, to be finalised.

Equipment wiring details and layout [internal and external]

Special fixing details

d. Builders Work Drawings:

These drawings may be prepared off site.

These are drawings prepared by the Contractor to detail all builders work required in connection with the Works, including but not limited to:

i. Dimensional plans and sections showing all holes required in walls, floors, roofs and ceilings.

ii. Special fixings required to the building fabric.

Sizes and positions of all access covers, panels and doors required in the building fabric for proper access to plant to enable inspection and maintenance to be effected.

e. Progress Drawings:

The Contractor shall keep on site, available for reference by the Contract Administrator, a full set of installation drawings on which he shall record progress and any deviations as the work progresses.

f. 'As Installed' Drawings:

These drawings may be prepared off site.

These are drawings to be prepared by the Contractor as a clear and proper record of the completed installations. These drawings shall be prepared on the same format and scale as the installation drawings and shall be handed over to the Contract Administrator prior to the issue of a Certificate of Practical Completion.

The drawings shall indicate the following requirements:

i. Dimensioned positions of all concealed services.

ii. Isolation facilities cross-referenced to the circuit charts.

iii. Controls devices cross-referenced to the wiring diagrams.

In the event of any of the 'As Installed' drawings not being completed owing to late amendments to the installation, a preliminary set of the 'As Installed' drawings so affected are to be handed over prior to the issue of a Certificate of Practical Completion.

A completed set of 'As Installed' drawings are to be handed over within two weeks of the date of Practical Completion.

Should it become apparent, prior to Practical completion that the Contractor will not comply with these requirements the Contract Administrator will have the right to immediately arrange for the drawings to be prepared by others. The whole of the costs involved in this, including all costs of surveying, shall be charged to the Contractor.

g. Programme for Production of Drawings:

The Contractor is to produce the Installation, Manufacturers and Builders Work drawings in accordance with a programme agreed with the Contract Administrator. Allowance is to be made in the programme for the checking and agreement process prior to Contract Issue.

The Contractor is to produce a schedule of information release dates at the start of the programme.

h. Co-ordination of Trades:

The Contractor is to obtain drawings and details of other works and with these, together with liaison with the other trades is to ensure that the Production/Installation Drawings take account of the positions and details of other works.

i. Drawing Submission Procedures:

The Contractor is to submit the Installation Builders Work and Manufacturers drawings [2 copies each] to the Contract Administrator for comment and agreement. When any necessary details have been commented upon and amended if required, the Contractor is to issue 2 copies of each of his drawings for distribution.

The Contract Administrator after examination of each drawings submitted for comment, will retain one copy and return one copy, commented on in the following manner:

i. Drawings found to be satisfactory:

Fabrication, manufacture or installation may proceed in accordance with the drawings submitted. Unless indicated to the contrary on such drawings, the Works shall comply with the Sub-Contract documents.

ii. Drawings found satisfactory subject to comment:

Fabrication, manufacture or installation may proceed in accordance with the drawings submitted subject to the Contractor taking necessary action based on the Contract Administrator's comments and all annotations added to the returned drawings, at his own risk. Unless indicated to the contrary on such drawings, the work shall comply with the Sub- Sub-Contract documents. Two copies of amended drawings shall immediately be forwarded to the Contract Administrator for contract issue.

iii. Drawings found to be unsatisfactory:

The Contractor shall re-submit drawings incorporating all comments and annotations added to the returned drawings. No work shall be fabricated, manufactured or installed until categories [a] or [b] are achieved.

Final comment on drawings [category [a]] will be conditional upon submission of supporting calculations, documentation samples etc.

iv. Co-ordination Drawings: the Contractor shall undertake the production of co-ordination drawings for Mechanical and Electrical services and attend such meetings with Contractors and the Contract Administrator as is necessary to achieve proper design co-ordination.

2.5 Builders Work: Unless otherwise called for by any the part of this specification, builders work will be carried out by the Contractor. The Contractor shall be responsible for obtaining details of all builder's work in connection with the installations from their suppliers.

2.6 The Contract Administrator's comments shall in no way relieve the Building Services Contractor of his responsibility to provide a completed installation suitable for its purpose or for the accuracy of his drawings. Modifications to the Contractor's drawings, as may be demanded by the Contract Administrator, shall not involve the Employer in extra expense.

2.7 The Contractor shall be responsible for the setting out of all builder's work arising from this installation.

2.8 The dimensional co-ordination between the building, the equipment and the services to be installed shall be to the Contractor's satisfaction. He will liase with the Contract Administrator to ensure adequate space for the proper operation and maintenance of the plant.

2.9 The Contractor shall be responsible for the removal and strip-out of all redundant materials and cabling. The provision of skips and removal of waste shall be by the Contractor.

2.10 All builders work shall be carried out by the Main Contractor, this shall include the forming of all holes required, making good, firestopping and finishing to a smooth paintable surface and painting to the Architects specification.

3 STANDARDS, CODES OF PRACTICE, REGULATIONS AND BYELAWS

3.1 STATUTORY AND LOCAL AUTHORITIES

All materials and installation techniques shall comply with:

a. The Health and Safety at work Executive

b. The Control of Substances Hazardous to Health Regulations 1988

c. Local Authority

d. Fire Brigade

e. Gas Board

f. Electricity Board

g. Water Board

h. The relevant British Standards and Codes of Practice

i. The Shops, Offices and Railways Act

j. Police Regulations

k. CDM Regulations

l. Disabled and Disabilities Act

3.2 CODES OF PRACTICE

All materials and installation techniques shall comply with the Regulations and Codes of Practice of:

a. The Chartered Institute of Building Services

b. The Institute of Electrical Engineers

c. British Standards

d. BS7671 Requirements for Electrical Installations (inc amendments)

3.3 MANUFACTURERS RECOMMENDATIONS

The design and installation shall be in accordance with the manufacturers recommendations for all plant and equipment.

The Contractor is to allow for the removal from site of all redundant/waste equipment and materials.

DIVISION 04 COMPLETION

1 DEFINITIONS

1.1 The installation shall be certified as practically complete after all services installations for which the Contractor is responsible have been installed, tested and commissioned in accordance with the specification and the tender documents and any subsequent variations to the Contract Administrator's satisfaction.

1.2 Testing shall be deemed to be the proving of the installation during construction.

1.3 Commissioning shall be deemed to be bringing the plant into use and demonstrating the specified performance. In order that the Employer may use the building for its intended purpose, including specific areas for their specified purpose.

1.4 Failures brought to light by testing or commissioning shall be rectified and the system re-tested and re-commissioned at no additional cost to the contract.

2 TESTING AND COMMISSIONING

2.1 Testing and commissioning shall be carried out by the Contractor as itemised in this specification. There will also be a requirement for additional inspections and tests during manufacture and erection as requested by good building practice, manufacturers recommendations, or as the Contract Administrator shall prescribe to prove the performance of the materials and the installation.

2.2 Codes of Practice for Testing and Commissioning: where published by the Chartered Institute of Building Services Engineers shall be followed. Where codes of practice are not published, or applicable, the manufacturer's commissioning procedure shall be carried out.

2.3 Measuring instruments or meters for testing and commissioning calibrated to the Contract Administrator's satisfaction shall be provided by the Contractor at no cost to the Contract.

2.4 Power shall be provided free issue by the Employer, however, connecting to the service provision as necessary to complete the testing and commissioning will be carried out by the Contractor at no charge to the Employer.

2.5 Before putting any plant into operation, the Contractor shall ensure the proper preparation and lubrication of all plant.

2.6 The Contractor shall provide the Contract Administrator with a programme showing salient dates for demonstrating the completion of commissioning before hand over.

2.7 Full facilities shall be provided by the Contractor for the Contract Administrator to witness the commissioning tests, but this will not absolve the Contractor of his obligations to ensure the proper running of the plant. The Contractor will give a minimum of five working days notice, in writing, for such witnessing.

3 PROVISIONS BY THE CONTRACTOR

3.1 Equipment guarantees associated with the installation shall be passed on to the user, they shall not in any way affect the Contractors obligations.

3.2 Tools and spares shall be provided to a schedule to be agreed with the Contract Administrator, generally in accordance with the manufacturer's recommendations, including special tools required, sufficient to maintain the installation for 12 months.

3.3 In order to satisfy Health & Safety requirements, final as-fitted drawings and manuals shall be provided prior to the date of practical completion. They shall comprise three sets of plans of the installation printed at full scale.

NOTE: Drawings shall also be issued on CD-Rom Autocad format, and in drawing (dwg) format and pdf format.

3.4 Operating and maintenance manuals must include:

a. A full technical description and scope of works for each of the systems installed, written to ensure that the Employer's staff fully understand the scope and facilities provided.

b. A technical description of the mode of operation and control of all systems.

c. Diagrammatic drawings of each system indicating principal items of plant, equipment, valves etc.

d. A photo-reduction of all record drawings to A3 size, together with an index.

e. A Legend for all colour-coded services.

f. Schedules [system by system] of plant, equipment, valves, etc., stating their model reference, locations within the building, duties and performance figures. Each item of plant, equipment, valves, etc., installed shall have a unique code number cross-referenced to the record and diagrammatic drawings and schedules.

g. The name, address, telephone and fax number and website of the manufacturer of every item of plant and equipment together with catalogue list numbers.

h. Manufacturer's technical literature for all items of plant and equipment, assembled specifically for the project, excluding irrelevant matter and including detailed drawings, electrical circuit details and operating and maintenance instructions.

j. A copy of all test certificates [including but not limited to electrical circuit tests, corrosion tests, type tests, works tests, start and commissioning tests] for the installations and plant, equipment, valves etc., used in the installations.

k. A copy of all manufacturer's guarantees or warranties.

l. Starting up, operating and shutting down instructions for all equipment and systems installed.

m. Control sequences for all systems installed.

n. Schedules of all fixed and variable equipment settings established during commissioning.

o. Procedures for seasonal changeovers.

p. Detailed recommendations as to the preventative maintenance frequency and procedures which should be adopted by the Employer to ensure the most efficient operation of the systems.

q. Lubrication schedules for all lubricated items of plant and equipment.

r. A list of normal consumable items.

s. A list of recommended spares to be kept in stock by the Employer, being those items subject to wear or deterioration and which may involve the Employer in extended deliveries when replacements are required at some future date.

t. Procedures for fault finding.

u. Emergency procedures, including telephone numbers for emergency services and out-of-hours call out.

g. A list of involved parties.

3.5 Presentation of Manuals: the manuals are to be A4 size in plastic covered, loose leaf ring binders with hard covers, each indexed, divided and appropriately cover-titled. Drawings larger than A4 shall be folded and accommodated in the binders so that they may be unfolded without being detached from the rings.

3.6 Temporary Manuals: provisional record drawings and preliminary performance data will be made available at commencement of commissioning or four weeks prior to completion, whichever is sooner, to enable the Employer's staff to familiarise themselves with the installation. These manuals shall be of the same format as the final manuals with temporary insertions for items which cannot be finalised until the installations are commissioned and performance tested. Two copies will be made available. Practical completion will not be granted until the temporary manuals are available.

NOTE: Manuals must also be issued on CD-Rom in "Word (.doc)" format and in PDF format.

3.7 All plant and apparatus shall be provided with nameplates giving the makers name, reference number, size, type, speed or any other relevant particulars. Valves shall be provided with a captive metal tag stamp numbered which shall refer to the valve chart to be provided with the as-fitted drawings.

3.8 As-installed drawings will indicate the as-installed routes of all relevant services including locations of equipment or accessories which will require checking or maintenance by service engineers which may be hidden by ceilings or finishes.

The drawings will indicate plant or equipment by name or reference which shall be cross-referenced to the schedules or charts included in the manuals or installed in plant rooms. Location of danger or special consideration shall be clearly indicated.

The as installed drawings are to include all details of the existing installation where necessary and relevant to provide complete and accurate record information.

3.9 The Contractor shall provide full instruction in the operation the maintenance of the completed installations and shall allow adequate time for attendance by a member of his staff fully conversant with the works and competent to instruct. These instructions are to be given at a time instructed by the Contract Administrator.

3.10 Two sets of as-installed drawings and one copy of the maintenance manual will be forwarded to the Contract Administrator for approval. The procedure will apply to temporary manuals and as-installed manuals.

One set of as-installed drawings and the maintenance manual will be returned marked up with comments and amendments. The Contractor will incorporate the comments and amendments and issue three sets of the as-installed drawings and manuals to the Contract Administrator for distribution.

An appropriate sum of money will be withheld from payment to the Contractor until approved documentation is received.

3.11 The Contractor shall prepare a maintenance schedule for approval in sufficient time to have this incorporated into the instruction manual prior to practical completion.

4 TEMPORARY HEATING AND LIGHTING

4.1 The permanent heating or lighting installation shall not be used without the written approval of the Contract Administrator and only then if the heating installations are sufficiently advanced.

4.2 Should the installations be used, the Contractor shall take responsibility for the operation, maintenance and remedial work, and arrangements for supervision and pay all costs arising including indemnifying the Employer against any reduction in manufacturers guarantee resulting from use before practical completion.

5 MAINTENANCE AND DEFECTS LIABILITY

5.1 Final examination shall be carried out at the end of the defects liability period. The comprehensive examination shall be carried out in conjunction with the Contract Administrator. Retention will not be released until the examination and items arising out of the examination are completed to the satisfaction of the Contract Administrator. If, in the opinion of the Contract Administrator, an adequate completion of defects cannot be attained, the right is reserved to have those works completed by others at the Contractor's expense.

5.2 All faults reported within the 12 months defects period shall be actioned within a 2-week period. Failure to do so will result in the works being completed by others and costs deducted accordingly.

DIVISION 05 STEEL CONDUIT, CABLE TRUNKING AND CABLE TRAY

1 SCOPE

1.1 The work shall comprise the provision of all plant, labour and materials necessary to supply and install a complete trunking, conduit and cable system and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the contract.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations, Current Edition

b. BS31 and 4568 Steel Conduit and Accessories

c. BS.731 Flexible Conduit

d. BS.4678 Cable Trunking and Accessories

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 Conduit shall be delivered in complete bundles and conduit accessories in boxes. Materials shall be kept in a secure store and protected from inclement weather and mechanical damage.

3.2 Trunking and accessories shall be delivered in complete bundles. Materials shall be kept in a secure store and protected from inclement weather and mechanical damage.

3.3 Cable tray and accessories shall be delivered in steel strapped bundles with local protection where necessary unless delivered by the manufacturers. After delivery cable trays shall be kept in secure store and protected from inclement weather and mechanical damage.

4 EQUIPMENT SELECTION

4.1 Trunking shall be manufactured to BS.4678 from zinc coated mild steel, galvanised finish.

4.2 Trunking of up to and including 100mm x 100mm shall be manufactured of not less than 18swg [1.2mm] steel sheet.

4.3 Trunking of sizes above 100mm x 100mm shall be manufactured of not less than 16swg [1.6mm] steel sheet.

4.4 Plastic cable trunking shall be manufactured to BS.4607 and shall be of white high impact rigid self-extinguishing polyvinylchloride.

4.5 Black enamelled heavy gauge welded steel conduit Class 2 to BS.4568: Part 1 shall be used for conduit work in any internal locations.

4.6 Galvanised heavy gauge welded steel conduit Class 4 to BS.4568: Part 1 shall be used for conduit work in any external or exposed locations including plant rooms.

4.7 Metallic flexible conduit shall comply with BS.731 and shall be of coiled steel with watertight sheet overall, terminating in manufactured couplers.

4.8 Where flexible plastic conduits are specified, they shall be to BS.4607 and shall be heavy duty PVC with wire reinforcement and manufactured couplers.

4.9 Cable tray to BS.729 shall, unless otherwise specified, be standard duty range with admiralty type perforation pattern.

4.10 Cable tray of sizes up to and including 300mm shall be manufactured of not less than 1.5mm gauge, hot dip coated galvanised mild steel.

4.11 Cable tray of sizes above 300mm wide shall be manufactured of not less than 2.0mm gauge hot dip coated galvanised mild steel.

5 EQUIPMENT INSTALLATION

Conduits and Accessories

5.1 Conduit runs shall be laid straight with easy sets and bends made only with approved bending machines or bending blocks.

5.2 Concealed conduits shall be securely fixed by crampets to prevent movement.

5.3 Spacer bar saddles shall be employed on all surface conduit work. Saddles are to be provided at intervals not exceeding 1200mm.

5.4 In surface conduit installations the use of three piece conduit unions shall be employed. Locknuts and running couplers will not be permitted.

5.5 Threaded conduits shall be the correct length so that conduit ends butt together in sockets and enter conduit boxes and fittings with tapped spout to the full length thereof.

5.6 Conduit terminations to loop in boxes or cable trunking shall be made by means of a socket and hexagon headed externally threaded brass bush. A flanged coupling, lead washer and hexagon headed bushes shall be used at distribution boards and adaptable boxes. Paint will be removed at the box and made good when the connection is complete. Earth continuity must be maintained.

5.7 All internal roughness, burrs, metal filings etc., shall be removed from conduits and accessories before fixing. Exposed threads shall not be left other than running joints in the complete conduit system. Running joint threads are to be thoroughly coated with best quality red oxide paint ready for Contract Administrator's finish or where no finish is applied enamel paint.

5.8 Efficient earthing shall be provided for conduit systems which shall be mechanically and electrically continuous throughout their length. Additional earth bonding in the form of heavy copper wire or tape must be provided where necessary to enable satisfactory earth continuity tests.

5.9 As far as possible, the Contractor is to avoid installing conduits across structural expansion joints, but where it is impossible to avoid crossing such joints, purpose made conduit expansion joints shall be provided.

5.10 These expansion joints are to be manufactured by an approved manufacturer.

5.11 Earth continuity shall be provided across expansion joints by bonding the nearest boxes either side of the expansion joint using a suitable copper earth wire.

5.12 A minimum clearance of 150mm shall be maintained between the electrical conduit and other mechanical services.

5.13 Cables or wires shall not be drawn into conduits before the conduits are fixed, all conduits shall be clean and free from water and oil before erection.

5.14 The Contract Administrator's approval shall be obtained for all conduit work before cables are drawn in.

5.15 The lead and return conductors of each circuit are to be drawn into the same conduit.

5.16 Conduits shall run parallel to building lines whether installed flush or surface.

5.17 Telephone cables and cables of differing categories shall be installed in separate and distinct conduit systems and are not to pass through conduits, boxes or trunking carrying wiring associated with other's parts of the installation.

5.18 Boxes shall be made of malleable cast iron finished galvanised and are to be manufactured in accordance with the appropriate British Standard specifications.

5.19 Boxes shall be securely fixed to the building structure independent of the conduits, and so that the whole of the conduit work is readily rewireable by means of round head sheradised screws. Brass screws shall be used externally.

5.20 Draw-in boxes must be adequately sized to prevent undue cramping of cables. The use of draw-in boxes, apart from outlets as detailed on drawings, shall be avoided in flush work and the conduit system shall be laid out with this in mind. In any circumstances however, the maximum run of conduit shall not exceed 10m where two right angle bends occur in the length of conduit without draw in facilities shall not exceed 5m. The Contract Administrator's approval of the provision and location of additional draw-in boxes shall be obtained.

5.21 Care shall be taken in the siting of all adaptable or draw-in boxes which shall generally be installed in walls at high level, unless ceilings are accessible.

5.22 Floor boxes, where unavoidable, shall be located below approved floor traps having recessed covers. In no circumstances shall floor boxes be installed without prior approval of the Contract Administrator.

5.23 Solid or inspection tees, elbows and normal bends with internal threads shall not be used. Inspection bends will only be permitted in surface conduit work of 32mm and larger and then only when a through box would otherwise be required adjacent to the bend.

5.24 Outlet boxes to which light fittings are attached, shall be 51mm fixing centres. No smaller box than this is to be used. Two conduit boxes per fluorescent luminaire in surface situations shall be used.

5.25 Terminal blocks shall be used in all boxes where a change in cable type is involved. They shall be of the fixed base type by an approved manufacturer.

5.26 Conduits cast into concrete shall be securely fixed by means of wire to reinforcing steelwork. Outlet boxes and adaptable boxes are to be securely fixed in position by means of pin head nails fixed to the shuttering in at least three positions to prevent the box from moving when concrete is being poured and/or vibrated.

5.27 Damage to conduit finishes shall be made good before the conduit is fixed.

5.28 Galvanised conduit shall be made good by applying an approved rust inhibitor followed by one undercoat and two top coats of a cold galvanised fluid applied in accordance with the manufacturer's instructions.

Black enamelled conduit shall be made good by applying an approved rust inhibitor followed by one undercoat and two top coats of best quality oil bound enamel applied in accordance with the manufacturer's instructions.

5.29 Fixings shall be suitable for the type and weight of material or equipment to be fixed. The Contract Administrator's approval shall be sought for the position and type of all fixings. In exposed or damp situations fixings shall be non-rusting or appropriately treated.

5.30 Screw fixings in brick, concrete or similar structural materials which necessitate plugging are to be made with 'Philplug' rawlplugs or other approved materials or devices. Screws used in exposed situations or where moisture is present, are to be of brass or other approved non-rusting material.

5.31 Heavy apparatus, cable track or equipment shall be secured by ragbolts securely grouted into walls and floors or other approved means determined by the nature of the structure.

5.32 Buried conduits shall be fully protected from mechanical damage e.g., when screeding operations are taking place.

5.33 Where conduit is buried in floor screeds it shall have at least 25mm cover over its entire length. The Contractor is to plan conduit runs before installation to avoid crossovers.

5.34 Where conduit is flushed into plastered walls, it shall have at least 15mm cover over its entire length. In walls, horizontal runs of flush conduit over 30mm in length will not be permitted without the written authorisation of the Contract Administrator.

5.35 In flush installations, all conduit, draw-in or adaptable boxes shall be provided with overlapping lids flush with the finished surface.

5.36 All boxes installed in plaster, plasterboard, suspended on concrete ceilings shall be installed flush to finished face unless otherwise specified.

5.37 Whenever surface mounted equipment is specified for use in flush conduit installations, a flush adaptable or conduit box is to be installed behind with the back of the equipment drilled and bushed. The adaptable or conduit box is to be concealed by the surface item of equipment.

5.38 Where conduit is specified in the ground externally, it shall be protected by means of Denso tape or equal and approved. The tape is to be half lapped and to be installed to 300mm above ground.

5.39 All fittings, when used in the open air, damp situations or where liable to come into contact with hygroscopic materials, must be heavily galvanised and all conduit boxes to be machine faced and fitted with suitable gaskets.

5.40 In areas such as ducts, kitchens and exterior or damp locations conduit and adaptable boxes are to be machine faced with machine faxed heavy gauge galvanised malleable iron lids and brass fitting screws. Gaskets shall be installed as directed by the Contract Administrator.

Flexible Conduits

5.41 Metallic flexible conduit shall be used for all final connections to motors and to equipment subject to vibration, detectors, thermostats etc, unless otherwise specified.

5.42 No flexible conduit longer than 900mm in length will be permitted as a final connection.

5.43 All flexible conduits shall be complete with circuit protective conductor which shall be connected at the supply end to a fixed earth terminal mounted in local isolator, isolating link box or conduit box, with the other end connected at the equipment earth terminal.

5.44 All trunking shall be installed parallel to building lines and shall be surface mounting unless otherwise specified.

Cable Trunking

5.45 Trunking and accessories are to be installed in the positions and as shown on the drawings and shall be manufactured from hot dipped galvanised sheet steel.

5.46 In order to reduce conduit runs the Contractor may be permitted to install further trunking than that specified, by application to the Contract Administrator in writing.

5.47 All trunking shall be sized in accordance with the IEE Wiring Regulations but with a limiting space factor of 33%.

5.48 The manufacturers data is to be strictly adhered to during the installation of trunking with regard to fixing, cutting, supports etc. Where trunking passes through floor slabs the Contractor shall allow to cast in sleeves.

5.49 All covers generally are to be arranged to be removable but sections of trunking passing through walls, floors etc., are to have fixed covers for the thickness of the wall or floor only.

5.50 The trunking lid shall be fixed either by:

a. toggle or spring strap operated by a recessed screw in the centre of the cover, or

b. metal thread screws entering hank bushes in the trunking

5.51 Trunking system joints shall be provided with purpose made connecting sleeves supplied by the manufacturer of the trunking. All trunking systems shall be both mechanically and electrically continuous with brass earth continuity links fitted externally between all joints.

5.52 All junctions, tees, bends and similar accessories shall be supplied by the manufacturers of the trunking and fitted by an approved method including gussets and continuity connections.

Bends for trunking shall be such that the minimum bending radius of the largest cable within them complies with IEE Wiring Regulations.

5.53 Site manufactured fittings will only be authorised where factory manufactured fittings are impracticable to provide a neat layout.

5.54 Apparatus connections shall be made by means of four sided terminating flanges, each termination to be fitted with a Paxoline sheet of 3mm thickness to cover the opening in the apparatus and cut and drilled for cables, the drilling for cables must be with as little tolerance as possible.

5.55 Expansion joints shall be fitted at not more than 15m intervals in straight lengths of trunking. The expansion joints are to be self-adjusting, fitted with copper bound bonding strip and to be to the Contract Administrator's approval. Similar expansion joints are to be fitted where trunking crosses an expansion joint.

5.56 Fire barriers: internal fire barriers of high density [32kg cu.m] resin bonded Rockwall with a maximum surface temperature of 175□C shall be installed where trunkings pass through walls, floors and fire barriers and additionally to prevent heat build-up in vertical channels by the Contractor. Where trunking or cable trays penetrate a fire barrier the barrier shall be cut to allow 20mm of mineral wool packing which shall be masked with a superlux plate in concealed areas or shall be to a detail to be agreed with the Contract Administrator in finished areas. This making good will be completed by the Contractor.

5.57 Retaining clips of the spring type as recommended by the manufacturer of the trunking shall be installed where trunking is running with the lid downwards.

5.58 Pin racks shall be installed in all vertical trunkings to avoid undue strain on cables. They shall be PVC coated to prevent abrasion of cables.

Plastic Cable Trunking

5.59 Trunking lengths shall be jointed by means of internal connectors, using solvent 'fixed' adhesive at one end and flexible cement or fire resisting mastic at the other end to allow for expansion. Allow expansion gaps in accordance with manufacturers recommendations.

5.60 All trunking shall be adequately supported from the structure at distances not exceeding those stated in the IEE Wiring Regulations.

5.61 In addition to the support requirement of the IEE Wiring Regulations, holes should be elongated to allow for expansion with screws and oversized washers for fixing.

5.62 Covers shall be of the clip-in type, finished white and of the same construction and manufacture as the trunking.

Cable Tray

5.63 Factory made accessories shall be used wherever possible and the need for on-site fabrication shall be kept to a minimum.

5.64 Cuts in cable tray shall have the bare steel edges protected by sealing with zinc rich paint for galvanised tray.

5.65 Cable tray shall be supported from the building structure at intervals recommended by the manufacturer, but at a maximum 1000mm distances by means of steel angle iron, channel, suspension rods or manufactured fixing clamps. All fixings to be hot dipped galvanised or site painted using "Galvafroid" or equal and approved.

5.66 The Contract Administrator's approval shall be obtained for all cable tray work before cables are installed.

5.67 The coupling of tray components shall be carried out as manufacturer's instructions but will normally be carried out by using M6 x 12mm galvanised or zinc plated bolts plus nuts and washers.

5.68 Bolts shall have domed heads to prevent any snagging or chaffing of the cable.

5.69 Couplers as supplied by the manufacturer of the trunking shall be fitted where cable trays join. A minimum of four bolts per coupler 8 per pair] shall be fitted.

5.70 Fixings shall be suitable for the type and weight of material or equipment to be fixed. The Contract Administrator's approval shall be sought for the position and type of all fixings. In exposed or damp situations fixings shall be non-rusting or appropriately treated.

5.71 Screw fixings in brick, concrete or similar structural materials which necessitate plugging are to be made with 'Philplug' rawlplugs or other approved materials or devices. Screws used in exposed situations or where moisture is present are to be of brass or other approved non rusting material.

5.72 Cable trays shall be supported at intervals to prevent undue deflection or stressing of the tray with an allowance of 25% for future capacity.

5.73 Cable trays, sizes shown on the drawings shall be checked by the Contractor prior to the installation to ensure that the cable routing planned by the Contractor for cabling not shown on the drawings does not affect the size of the cable trays.

Where the size of the cable tray is not shown the Contractor will size trays to allow a flat formation of cables with spacing between cables.

5.74 Cable fixings shall be metal clips or saddles with PVC insulation overall or by cable cleats. Cable straps or binding tape will not be permitted.

5.75 Wherever holes are cut into the tray the Contractor shall supply and fit brass bushes to accommodate cables.

5.76 Where mineral insulated cables are specified for use with cable tray supports, cable is to be PVC sheathed overall to avoid contact between dissimilar metals.

DIVISION 06 CABLES AND WIRING

1 SCOPE

1.1 The work shall comprise the provision of all plant, labour and materials necessary to install a complete cabling and wiring system, and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the contract.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations:

b. BS.5467 Armoured Cables with Thermosetting Insulation for Electrical Supply.

c. BS.5593 Impregnated paper-insulated cables with aluminium sheath/ neutral conductor and three shaped aluminium phase conductors [CONSAC], 500/1000V, for electrical supply.

d. BS.6004 PVC Insulated Cables [Non-Armoured]

e. BS.6007 Rubber Insulated Cables

f. BS.6207 Mineral Insulated Cables

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 Cables are to be delivered to site with the manufacturers seals and labels intact.

3.2 Labels are to be kept on site and are to be made available for the Contract Administrator's inspection as required.

3.3 All cables are to be stored in a secure area protected from inclement conditions and mechanical damage.

3.4 Cable sizes specified shall be checked against equipment that the cable connects to before installation. Where cable sizes of a higher rating than that of the switchgear are specified the Contractor shall supply and install reducing sockets for terminations.

4 EQUIPMENT SELECTION

4.1 Reduced neutral conductors shall not be used unless indicated.

4.2 All cables are to be LSOH in specification throughout and selected from the harmonised colour selection.

4.3 An over sheath or serving, of the manufacturers standard colour, shall be provided unless otherwise indicated.

4.4 Elastomer [EPR] and Polyvinyl chloride [PVC] insulated only, single core general purpose wiring cables to BS.6004 shall be 450/750 volt grade reference 6491X or BS.6007.

4.5 Polyvinylchloride insulated and sheathed flat cables [PVC/PVC] with base circuit protective conductor [CPC] to BS.6004 shall be 300/500 volt grade reference 6242Y and 6243Y.

4.6 PVC/SWA/PVC cables to BS.6346 are to be 600/1000 volt grade with conductors of copper and the single wire armouring is to incorporate hard drawn tinned copper earth continuity conductors.

4.7 Thermosetting [XLPE] insulated cables up to and including 3.3kV shall comply with BS.5467 and BS.5468.

4.8 Thermosetting [HEPR] insulated cables up to and including 3.3kV shall comply with BS.5467 and BS.5469.

4.9 Mineral insulated copper sheathed cables shall be of solid drawn, totally inorganic construction, free of additives BASEC approved and manufacture din accordance with British Standards. All cables of 5mm² and over will be heavy duty 1000 volts sheathed orange or red or unsheathed with PVC shrouds at terminations. Cables are to be manufactured by BICC Pyrotenax Limited.

4.10 Mineral insulated copper sheathed cables shall be BASEC approved and manufactured in accordance with British Standards. All cables up to 4mm² will be light duty 600 volts sheathed orange/white/red*** to be specified on individual specification** or unsheathed with PVC shrouds at terminations. Cables are to be manufactured by BICC Pyrotenax Limited.

4.11 Fire resistant cable [FP200] shall have an aluminium/PVC laminate and PVC composite flame retardant sheath with tinned copper circuit protective conductor. Conductors shall be solid or stranded plain annealed copper with extruded silicone rubber insulation.

4.12 Flexible cords used partly or wholly for the suspension of pendant luminaires shall be unkinkable white circular, 300/500 volt to BS.6500 Table 16 PVC insulated PVC sheathed with tinned high conductivity stranded copper conductors, of minimum size 1.0sq.mm. No flexible cord shall support a mass in excess of 5kg.

5 EQUIPMENT INSTALLATION

General

5.1 All cables are to be installed along routes and at levels indicated on the drawings or as described, and are to be to the Contract Administrator's satisfaction.

5.2 Damage to cable serving or armouring shall be brought to the notice of the Contract Administrator in order that instructions for repair or replacement can be obtained.

5.3 Surface cables shall be supported by means of cleats, hangers or secured to cable trays by means of purpose made clips. The size of cable cleats are to be so selected that they can be tightened down without exerting undue strain on the cables over the full range of operating temperatures.

5.4 Cleats or fixings shall be spaced in accordance with the fixing centres given in the appropriate table of the IEE Wiring Regulations for Electrical Installations.

5.5 Single cleats shall be fixed direct to the structure. Where two or more cables are run in the same direction, the cleats shall be fixed with suitable straps or purpose-made supports.

5.6 Cable supports shall be provided to each side of a bend or set and at all terminations to equipment.

5.7 Additional hangers shall be provided on cable routes which are subject to numerous changes in level and direction.

5.8 Clearance of 300mm is to be maintained between cables and any equipment, pipework, etc.

5.9 Where cables pass through walls, floors or foundations they shall pass through ducts or holes in the structure or be protected by conduit or suitable sleeve material. The ducts and holes shall be free from sharp or rough edges.

5.10 Terminations and jointing: all cable terminations to equipment or switchgear shall be carried out by personnel having experience of making joints on the type of cable specified.

5.11 Crimped lugs etc., shall be made with a crimping tool recommended by the manufacturers of the cable and fitted with clips specifically designed for crimping each type of cable.

5.12 Cable terminations shall be fitted with compression type glands tightened to grip both the inner and outer PVC sheaths and armouring.

5.13 Cable conductor terminations at switchgear etc., shall be made by one of the following methods:

a. When cable size permits directly into clamps or pinching screw tunnel terminals.

b. Fitted with purpose-made cable lugs or reducing sockets securely crimped to the conductor.

5.14 Voltage drop shall not exceed 3.0% of the nominal voltage between the consumers terminals and any point in the installation for lighting installations and 5.0% for other uses. Lift supply cable voltage drops shall be limited to 2.5%.

5.15 Cable lengths shown on any drawings are for calculation purposes only. The Works Contractor shall not use these details for ordering cables without satisfying themselves that the measurements are accurate.

5.16 Each cable will be supplied on one length, no through joints will be allowed without written permission.

5.17 Tee joints and when specifically requested, straight through joints in PVC insulated, single wire armoured and PVC sheathed cables, shall be made within a cast iron protection box, incorporating internal armour clamps, filled with hot pouring compound [e.g. BICC Compound G8] or cold pouring compound [e.g. BICC Compound G93].

Joints between paper insulated cables and PVC insulated cables shall be within a pressed copper box which shall be plumbed to the sheath of the paper cable. The plastic cable shall be sealed with polyester impregnated tape. The inner box shall be filled with hot pouring compound. The complete joint shall be enclosed in a cast iron protection box filled with hot pouring compound.

The joints and straight through joints shall be made using hot tinned copper 'weak-back' jointing ferrules. Tee joints shall be married and sweated.

Cables shall be jointed colour to colour throughout the installation. Where coloured cores are to be jointed to existing numbered cores the Contractor shall ascertain from the Supply Authority the system in use at the particular site or for the particular installation.

The bonding of the armouring shall be outside the outer protection box and shall be of 70mm² minimum section. The minimum thickness of compound between the cores of the cable and the sleeve or box shall be 12mm.

Immediately after installation, cables shall be tested with a 500 volt test set to demonstrate that the insulation resistance between cores and earth is satisfactory.

A cable shall not be cut until the jointing or terminating commences and the work shall proceed continuously until it is completed. All necessary precautions shall be taken to prevent damage and ingress of moisture and impurities; cable ends shall be free from moisture before jointing commences and, in the case of paper insulated cables, a sample of paper shall be tested for moisture. Where circumstances prevent completion the cable ends shall be sealed. In the case of lead sheathed cables this shall be by plumbing and for aluminium sheathed cables by hermetically sealing.

5.18 At terminations, armouring and metal sheaths shall be connected directly to the external earthing terminal of the equipment by a bonding conductor. For LV cables the bonding conductor shall have a cross sectional area in accordance with the IEE Wiring Regulations, and for HV cables it shall be as indicated. Metal sheaths of single core cables shall be bonded and earthed at one point only, as indicated; insulated glands shall be used at the open circuit end or ends.

5.19 At terminations, cable tails shall be formed by separating and bringing out the cores. Each tail shall be long enough to connect to the terminals of the equipment.

5.20 At the termination of single core cables, gland plates shall comply with IEE Regulations. For three phase circuits the phase conductors shall be arranged, if possible, in trefoil formation where they pass through the enclosure or equipment.

5.21 Core identification at terminations shall be by coloured or numbered plastic stretch or shrink ferrules.

5.22 Continuity of spare cores shall be maintained at joints, and at terminations the cores shall be connected to spare terminals.

5.23 Cables shall not be installed under tension and allowance must be made for movement of the structure and/or ground subsidence. Where the run of cable changes direction the radius or curvature shall be within specified limits and any special bending tools recommended by the manufacturer shall be used. Due care shall be taken to ensure the installation of cables complies in all respects with all general and particular instructions issued by the cable manufacturer.

5.24 The Contractor shall include for the supply and fixing of suitable cable, dividing boxes direct to the switchgear or distribution board. Each cable core shall terminate in a brass ferrule suitable for use with the particular switchgear.

5.25 Cables laid in ground shall be trenched to a depth of 600mm unless otherwise specified. The Contractor shall lay the cables on a bed of fine stone dust, 75mm in depth and dressed over with a further 75mm layer of fine stone dust.

The trench shall then be backfilled to a depth of 300mm. Yellow PVC modular tape indicating “Electric Cables” shall be laid at this depth.

The trench shall be backfilled and area reinstated, grass seed and topsoil shall be used where turfed areas require replacement to match surrounding area.

Where cables are run under gardens or planted areas, they shall be protected by interlocking cable tiles of an approved pattern. Under paved or metalclad roadways, they shall be drawn into hepduct clay conduits.

Cables rising out of the ground and fixed to external walls or structures, shall be protected from mechanical damage by means of approved heavy gauge galvanised steel capping fixed to the wall to a height of 1800mm.

5.26 Cable runs shall be made straight, parallel and at right angles to the sides of the building.

All risers and drops shall be vertical.

<u>PVC Insulated Only Single Core Cabling</u>

5.27 The installation of PVC insulated single core cable shall generally be in conduit or trunking. The Contractor shall install cables of the sizes as shown on the drawings.

5.28 Where PVC insulated single core cables are drawn into conduit the Works Contractor shall ensure that the conduit system is completed prior to the drawing in of cables. Care shall be taken that there are no burrs of rough edges.

5.29 Numbers of PVC insulated single core cables drawn into conduits shall not exceed those shown in the appropriate tables in the IEE Wiring Regulations for Electrical Installations.

5.30 PVC insulated single core cables laid in trunking shall be bunched and bound to form the individual circuits at 2000mm intervals. Numbers of cables laid in trunking shall not exceed the manufacturers recommendations and the appropriate table in the IEE Wiring Regulations for Electrical Installations.

5.31 No cable less than 1.5sq.mm live conductor size shall be permitted. All cables shall have stranded conductors, including 1.5 sq.mm and 2.5 sq.mm sizes. Insulation colours shall be in accordance with IEE Wiring Regulations.

5.32 All cable ends shall be clearly marked with phase colour and circuit number, using cable markers.

5.33 Other than at accessories or equipment, no joints will be permitted without the authorisation of the Contract Administrator.

5.34 No PVC insulated cables shall be used for final connections to any accessory, appliance or luminaire where any transfer of heat detrimental to the cable insulation or termination is possible. Where PVC insulated cables are specified for final connection to or installation within such accessories, appliances or luminaires, the individual cores of the cables shall be provided with additional heat-resisting sleeving.

5.35 All bolted connections shall be made by means of crimped compression lugs and spring washers. No soldered connections will be permitted.

5.36 Circuit protective conductors shall be used throughout metallic and non-metallic conduit and trunking installations and where not detailed on the drawings or schedules, shall be sized in accordance with the Wiring Regulations.

5.37 All conductors of each circuit shall be enclosed in the same steel conduit or trunking. Single core cables must not enter steel enclosures through separate holes.

<u>PVC insulated and sheathed flat cables with bare CPC</u>

5.38 PVC/PVC run on the surface shall not be employed for high voltage or three phase circuits.

5.39 All cable shall be relevant British Standard and colour coded to the latest requirements of the IEE Wiring Regulations.

Cables shall be fixed securely at not more than 150mm centres.

The minimum sizes of conductors for lighting or power points shall be 1.5mm for lighting and 2.5mm for power.

5.40 No PVC insulated and sheathed cable shall be run within or in contact with building fabric insulation.

5.41 All joints and interconnections shall be carried out only in the terminals or distribution gear, lighting outlet boxes, luminaires or accessories. The use of joint boxes shall not be permitted. Cable cores shall be sheathed with heat-resisting sleeving where entering luminaires and heat-emitting equipment.

5.42 All cables shall be run directly off reels and not taken from loose coils.

5.43 All cables shall be installed wherever possible in wall chases, ducts, floor or ceiling voids, parallel with building lines and neatly dressed.

5.44 Wherever possible cables shall be passed through the open web of beams and not through notches cut in fitting pieces. Joists are not to be notched but may be drilled after obtaining the permission of the Contract Administrator. Where cables are installed transversely through ceiling or floor joists, they shall normally be run in holes drilled through the centre of joists. Where this is not possible they shall be 50mm, minimum measured vertically from the bottom or top respectively of the joist.

5.45 No PVC insulated and sheathed cables shall be permitted in floor screeds. Where cables are specified to be run on the surface or flushed into walls, they shall be protected by metal conduits as detailed in the relevant division of this specification and comply with IET regulations. Open ends of all conduits are to be finished with suitable bush.

5.46 Cables in roof voids shall be clipped to the sides of joists or trusses clear of insulation and where crossing joists shall be clipped to trusses wind bracing or battens. Where battens are employed they shall be supplied and installed by the Contractor.

5.47 Where cables are specified to be run within ceiling voids on catenary wires the installation shall comply with the IEE Wiring Regulations. Cables shall be supported using 20mm wide insulating tape of at least three complete turns and buckle clips or cable strapping at 300mm intervals. Catenary wires shall be installed at sufficient tension to avoid sagging on completion of the wiring installation by means of adjustable eye bolts securely fixed to the structure. All catenary wires shall be effectively bonded in accordance with the Wiring Regulations.

5.48 Surface fixings shall generally be by means of PVC/nylon single pin clips or saddle type clips. Cables run in the same direction shall be separately clipped except where multi-cable runs occur when cable tray, timber battens or backboards shall be supplied and installed by the Contractor.

5.49 Care shall be taken to eliminate any strain or stress on the PVC sheathing.

Where cables are buried in walls, floors, ceilings etc., they shall be protected by galvanised capping or high grade PVC capping pinned to the walls.

5.50 Where enclosed ceiling light fittings or bulkhead fittings are specified, a conduit box shall be fixed into the ceiling or wall behind the fitting to contain heat-resistant sheath connectors, and allow heat resisting cables to be connected into the light fitting.

In instances where multiple connections are unavoidable, they shall be enclose din a suitable adaptable box. The backs of metal boxes shall be lined with SRBP insulating sheeting. Where multiple cable connections are permitted, connectors must be fixed in the base of the adaptable box.

No more than 3 no. conductors will be permitted at any one termination.

Where PVC type cables are employed with metal boxes, the entries shall be bushed with PVC or rubber grommets.

5.51 PVC cables to be installed in fluorescent fittings shall only enter the fitting spine in a position whereby it avoids the cables passing the choke.

5.52 Conductors used as meter tails shall be PVC insulated and sheathed, sized and colour-coded to Electricity Board requirements. The installer shall consult with the Electricity Board to determine any special meter tail requirements or termination features.

5.53 Circuit protective conductors shall terminate in the appropriate terminal of the accessory or equipment. All circuit protective conductor cables shall be adequately sheathed with yellow/green PVC sheathing.

5.54 In certain instances it will be permissible for vertical cable runs to be installed in the cavities of internal walls, but only where the cable drop does not exceed 5 metres in length. Where the cables pass through the wall, they shall be installed in round conduit grouted into the wall. The conduit shall extend clear of the wall on both sides and be fitted with a bell mouth bush fitted at each end.

5.55 Where cables are concealed in plaster walls they shall be protected by round metal conduit. The conduits shall be securely held in position by crampets. Where a number of accessories are mounted above and below each other, round heavy gauge steel conduits shall be used. The conduits shall project 25mm into the void and have ring bushes fitted.

Conduits buried in plaster shall have a minimum 6mm depth of cover over its entire length.

Flush mounted metal clad accessories shall be fitted with a male bush in hollow partition walls.

5.56 Wiring to accessories on fair faced brick or blockwork shall be protected by heavy gauge black enamelled or galvanised conduit as appropriate from within the ceiling cavity. The conduit shall project 25mm into the ceiling cavity.

All runs shall be made straight, both parallel with and at right angles to the side of buildings. All risers and drops shall be vertical.

5.57 Wiring accessories on hollow partitions shall always be from the ceiling space above. Where drops occur, the cables shall be left fixed and neatly coiled above the point where the cable drop occurs until the ceiling panels are erected, when they will be passed through a 25mm diameter hole in the panel by the ceiling erector. Where a large number of cables enter a partition at one point, such as for a distribution board, a series of 25mm diameter holes in line will be provided. Where necessary, the cables shall be supported by nylon straps. Should it be necessary run cables horizontally through the holes in vertical mounted studs, then these holes shall be fitted with a rubber grommet.

Flush mounted metal clad accessories shall be fitted with a male bush in hollow partition walls.

To prevent overheating of cables in hollow partitions they shall be kept at a minimum distance of 750mm from any heating pipe and horizontal runs of cable passing heating pipes will not be permitted.

5.58 Concealed drops to distribution boards shall enter at the back of the distribution board with the cable entry fitted with a suitable grommet strip secured by high impact adhesive.

Surface drops from false ceilings shall be in cable trunking, with the cable finishing 25mm above ceiling level. A suitable grommet strip secured with impact adhesive shall be fitted to the upper end of the trunking, the lower end being fixed to the distribution board with a manufactured end flange. The trunking shall be fixed to the wall with 1¼“ x no. 8 RH black japanned wood screws in plastic wall plugs. The hole cut in the distribution board shall be fitted with grommet strip secured with impact adhesive.

<u>PVC insulated single wire armoured and PVC sheathed power cables</u>

5.59 Terminations of PVC/SWA/PVC cables shall be brass compression glands of an approved type. For interior work only a wire armour clamp finished in brass is required. For exterior work and there the minimum degree of protection required is IP55 then a weatherproof gland assembly, finished brass, shall be used. Serrated tempered zinc steel washers shall be used for all terminations up to 32mm diameter, where the gland diameter exceeds 32mm diameter a minimum of two heavy gauge galvanised block nuts shall be used with the termination.

Brass earthing tags bolted with brass nut, bolt and serrated washers to the switchgear enclosure, and PVC shrouds, shall be installed at all terminations.

5.60 PVC/SWA/PVC cables run internally within the building shall be supported by “claw” type saddles securely fixed to the main structure, or where specified on cable trays. The maximum spacings for fixings shall be 450mm for vertical runs and 350mm for horizontal runs.

5.61 Where cables are installed in inaccessible ducts, brackets and chair rollers shall be installed.

5.62 Joints shall not be subject to corrosion due to contact of dissimilar metals or the use of corrosive or acidic solder fluxes. Joints must be protected from moisture with the sheaths of cables taken inside joint boxes.

Cross linked polyethylene insulated power cables and low smoke and fume sheathed cables

5.63 Cables will generally be installed as the PVC insulated version of that cable. However, the contractor's attention is drawn to the fact that the sheathing of these cables is generally less robust than PVC and therefore extra care must be taken when installing such cables.

Mineral insulated metal sheathed cables

5.64 Where MICS cables are run on the surface, these shall be fixed by single or multi-way heavy duty gauge PVC covered copper saddles. Cables shall be spaced off the wall or ceiling surfaces by spacer bar saddles.

Saddles shall be fixed by means of brass round head screws which shall be plugged as required.

Fixing saddles shall be installed at the maximum intervals indicated below:

Overall Cable	**Maximum Spacing of Saddles**	
diameter [mm]	Horizontal [mm]	Vertical [mm]
Up to 9	600	800
9 to 15	900	1200
15 to 20	1500	2000

Where MICS cables are installed on cable trays, PVC covered copper saddles shall be used as above but spacer bars are not required.

All cables on cable trays shall be arranged so that these cables are only two tier in formation.

Where factory made brackets are not available, and with the approval of the Contract Administrator, flat PVC covered copper strip may be used as purpose-made brackets.

All fixing brackets shall be made from orange PVC covered copper tape.

The size of PVC covered strip shall be determined as follows:

No. of Cables	Cable diameter [mm]	Width of strip [mm]
Up to 4	Up to 9	9.5
	Up to 14	12.7
	Up to 25	16.0
More than 4	Up to 9	12.7
	Up to 14	16.0
	Up to 25	19.0

PVC covered copper strip shall be used for all multi-combination of MICS cables routed on cable trays or directly on walls or ceilings. The fixings of saddles on trays shall be by machined brass round head screws, M3.5 or equivalent, locking washers and securing nuts.

5.65 MICS Terminations: all terminations shall be of the same manufacture as that of the cable. Terminations will be cold screw-on seals for MICS cables and shall comprise a brass screw-on pot, sealing compound, a stub cap closure and conductor insulating sleeving.

Seals shall be complete with compression ring gland and PVC shroud in all situations other than where boxes with special MICS clamps have been specified.

A termination shall be fitted at each end of any length of cable and this shall be fitted as soon as the cable ends have been prepared.

MICS cables shall be terminated using the appropriate cable manufacturers' recommended tools and techniques.

Sufficient cable sheath shall be cut back and removed so that the conductors reach the necessary terminal without any strain and with no joints in the conductor.

Cable tails shall be insulated with black neoprene sleeving which shall be pushed over the stubs on the pot cap.

All tails shall be identified with suitable coloured sleeves or collars which shall cover a minimum of 25mm length of the neoprene sleeving. PVC insulating tape will not be acceptable for this purpose.

Where the conductor is 2.5mm² or less the tail end shall be bent upon itself where it enters the terminal connection in order to present sufficient surface area to any pinching screws or clamps.

Conductors of 6mm² and over shall be terminated with cone grip type cable sockets and these shall be lug, tag or stud type as required.

Where the cable terminates at conduit boxes or similar equipment with tapped spout entry, the cable gland shall be screwed directly into the tapped spout.

Where required, reducing sockets shall be used; the minimum size of entry shall be 20mm diameter. Earth tail seals will be used at all cable terminations.

5.66 At terminations to electrical equipment such as switchgear, distribution boards, control gear, trunking and adaptable and mounting boxes, clearance holes shall be drilled into the electrical equipment.

MICS cable glands shall be terminated into a machined conduit coupler and this shall be connected to the electrical equipment.

Final connection shall be by male hexagonal smooth bore brass bush and serrated washer within the electrical equipment so that the shoulder of the bush is pulled up tightly against the inside of the closure.

Locknuts and female brass rings shall not be permitted under any circumstances.

5.67 Cables shall only be installed by tradesmen who are conversant with the handling and jointing of MICS cable and they shall at all times only use bending, stripping and sealing tools as recommended by the manufacturer.

5.68 Wherever possible MICS cables shall be installed within roof and ceiling voids, partition or enclosed below plaster depth within walls.

5.69 Under no circumstances shall MICS cable be installed direct in floor screeds. Where the cable route traverses a floor the Contractor shall install the MICS cable within HG PVC conduit embedded in the screed. The conduit diameter shall be a minimum if four times the diameter of the cable, with a minimum diameter of 20mm. No more than two cables shall be installed in any one conduit. Conduits shall extend a minimum of 150mm above the finished floor level or to the accessory mounting box, whichever is appropriate. The formation of 90□ bends in MICS cables shall have a radius of not less than 12 times the diameter of the cable.

5.70 MICS special precautions: where cables pass through walls and floors, are concealed behind skirting boards or may be subject to damage or abuse [i.e. where cables rise from the ground] they shall be protected up to a height of 1375mm with heavy gauge PVC conduit.

In external and other damp situations and where glands are screwed into aluminium alloy fittings, bitumastic paint shall be applied to the junction between gland and fittings and to any exposed threads to avoid corrosion.

Ends of cables which must be left unfixed due to the building construction must be coiled and secured to a temporary fixing and not supported solely by the cable.

All ends of cable which are not permanently sealed by glands must be sealed by a liberal external application of sealing compound, held in position by self-adhesive PVC tape.

5.71 MICS Testing: in addition to the standard tests as required by the IEE Wiring Regulations, the Contractor shall carry out insulation resistance tests, with a 500 volt Megger or equivalent, to every seal and length of cable directly after installation and 24 hours thereafter.

Where the Contract Administrator has approved the installation of MICS cables in PVC conduit within floor screeds, then these cables shall be tested shortly after the concrete has been poured, while the concrete is still green.

Where cables are run behind pinned ceilings, tests shall be carried out immediately after the ceilings have been installed and before decorations commence.

In all cases the tests shall give an infinity reading between separate cores and cores to sheath.

5.72 Ends of cable which must be left unfixed due to the building construction must be coiled and secured to a temporary fixing and not be supported solely by the cable. All cable ends which are not permanently sealed by glands must be sealed by a liberal external application of sealing compound, held in position by self-adhesive PVC tape.

Surge Voltage Suppression

5.73 In order to protect the mineral insulated cables against surge voltages, the Contractor shall ensure that surge voltage suppressors are fitted across the terminals of any contactor and also any 3 phase star connected motors.

5.74 Where MICC cables are specified for final connections to motors or equipment subject to vibration, the Contractor shall install a loop into the cable immediately before termination. The loop shall not be less than the minimum bending radius of the cable as previously mentioned and shall not come into contact where passing across its own run.

Silicon rubber insulated aluminium/PVC laminate and flame-retardant PVC sheathed cable

5.75 Where FP200 fire resistance cables are specified then extra care shall be taken when preparing the cable ends for terminations. The cable sheath shall first be removed by scoring around the PVC with a knife or approved cable scribing tool. The PVC shall not be cut through to the aluminium foil. The sheath shall then be removed by gently flexing at the point of scoring until the sheath fractures.

5.76 FP200 earth continuity shall be provided by the bare tinned copper circuit protective conductor with no additional connection to the aluminium sheath.

5.77 When making terminations, care shall be taken to avoid bending the cores over the edge of the aluminium foil to avoid damaging the insulation. To avoid damaging the insulation, heat shrink tubing or a suitable plastic ferrule shall be used over the core/foil interface before splaying out the cores. The cable sheath shall not be allowed to protrude into the terminating box.

5.78 Where terminations are carried out in tight enclosures the insulated and circuit protective conductors shall be over-sleeved to avoid pinching of the insulation. Cables shall be terminated in a box using a PCP sealing ring shroud and the appropriate compression ring.

5.79 The fixing of FP200 cables shall be as for MIMS cables, with the exception that colour co-ordinated PVC sheathed metal P clips or metal cable ties shall be used when provided as part of a fire alarm installation.

6 TESTING

6.1 Testing and commissioning shall be in accordance with the IEE Wiring Regulations for Electrical Installations.

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

6.3 Where necessary to prevent damage to components of equipment the equipment shall be disconnected for the duration of the relevant tests.

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

7 LABELS AND NAMEPLATES

7.1 Labels shall be fitted to PVC/SWA/PVC cables and MICS cables where they leave or enter an item of switchgear and where they peel off from main cable routes. The Contractor shall submit a sample of his proposed cable label to the Contract Administrator for his approval. The label will indicate the number of cores, phase, conductor size and type i.e. copper or aluminium and the cable reference which shall refer to the as-installed main schematic.

DIVISION 07 WIRING ACCESSORIES: GENERAL REQUIREMENTS

1 SCOPE

1.1 The work shall comprise the provision of all the plant, labour and materials necessary to install the system of fittings for lighting and power and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the contract.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. BS.67 Ceiling Roses

c. BS.546 Two Pole and Earth Plugs and Sockets

d. BS.1363 13 Amp Plugs Switched and Unswitched Socket Outlets

e. BS.3676 Switches for Domestic and Similar Purposes

f. BS.5733 Requirements for Electrical Accessories

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 Equipment and fittings shall be delivered to the site in complete boxes providing adequate protection in transit. Materials and fittings shall be kept in a secure store and protected from inclement weather and mechanical damage.

4 EQUIPMENT SELECTION

4.1 All accessories, switches and socket outlets shall be of the type shown on the drawings [or approved equal] and as specified in the relevant divisions elsewhere in this document. Accessories are to be selected from the MK logic plus range with regard to the Part M regulations. The power socket outlet and fused connection unit accessories are to be complete with red rocker switches to allow easy identification.

4.2 Fixings of accessories shall in all cases comply with the recommendations of the manufacturer.

4.3 Accessories shall generally be as manufactured by MK Limited. Externally mounted accessories shall be as their Masterseal Range.

5 EQUIPMENT INSTALLATION

5.1 Accessories at different heights shown on drawings as adjacent to each other, shall wherever practical, be arranged so that the centre line of the accessory box is in vertical alignment with other boxes either below or above. Any queries relating to the setting out of accessory boxes must be referred to the Contract Administrator.

5.2 Lighting switches shall be mounted at 1000mm above finished floor level unless otherwise specified in the relevant division.

5.3 Flush lighting switches shall be mounted in zinc plated steel boxes of a minimum 35mm depth unless otherwise specified in the relevant division. Metal boxes shall be securely fixed to the structure independent to the conduit.

5.4 Surface lighting switches shall be mounted in aluminium finish steel boxes to match the finish of the accessory unless otherwise specified in the relevant division. Metal boxes shall be securely fixed to the structure independent to the conduit.

5.5 Ceiling pull cord switches shall be rated at 15/20 amps and be mounted direct to recessed boxes in the ceiling, fixed independently of the ceiling direct to the structure.

5.6 All boxes shall be fitted with an earthing terminal. Where earth continuity is not by means of a metallic conduit system the final sub circuit earth continuity conductor shall be connected to the earth terminal.

5.7 No PVC insulated cables shall be used for final connections to any accessory, appliance or luminaire where any transfer of heat detrimental to the cable insulation or termination is possible. Where PVC insulated cables are specified for final connection to or installation within such accessories, appliances or luminaires, the individual cores of the cables shall be provided with additional heat resisting sleeving.

5.8 Pendant Sets: shall consist of a category T2 heat resistant lampholder, heat resisting PVC insulated and sheathed flexible 0.75mm² circular cable complying with BS.6141 and a ceiling rose fitted with two terminals plus loop-in and earth/strain. For fittings of less than 5kg the strain wire may be connected to the earth terminal. Heavier fittings will be supported to BS67 normally by separate ceiling hook. The base of the ceiling rose will incorporate knockouts to facilitate off-centre cable entries. The base will also be suitable for mounting over small circular conduit boxes to BS.4568.

5.9 Plug-in lighting roses: shall comply with the requirements of BS.6972 and BS.7001 consisting of components where the live contacts are inaccessible and the earth contact is made first as the plug is inserted into the socket. Where plug-in lighting roses are used for the support of pendant luminaires, the weight of the luminaire will not exceed 5kg.

5.10 Socket outlets shall be mounted not lower than 400mm from the finished floor level to the underside of the outlet plate and 150mm above work surfaces when shown or specified above fixed benching.

5.11 Flush mounted socket outlets shall be mounted in zinc plated steel boxes of a minimum 35mm depth unless otherwise specified in the relevant division. Metal boxes shall be securely fixed to the structure independent to the conduit.

5.12 Surface socket outlets shall be mounted in aluminium finish steel boxes to match the finish of the accessory unless otherwise specified in the relevant division. Metal boxes shall be securely fixed to the structure independent to the conduit.

5.13 All boxes shall be fitted with an earthing terminal. The earthing terminal of every socket outlet shall be connected to the earthing terminal in the box by a conductor having minimum cross-sectional area of 4mm.

5.14 Socket outlets mounted in underfloor trunking boxes shall be of a type suitable for the box depth.

5.15 Where socket outlets are specified for internal, damp or exterior locations, they shall be complete with integral residual current device of 30mA sensitivity.

5.16 In kitchens, refrigeration and plant rooms socket outlets shall be complete with neon indicators.

5.17 Fused connection units to BS.5733 shall be of the same finish as the socket outlets in any area and shall be double pole, switched unless otherwise specified, and complete with flush or surface box and protective conductor terminals as for socket outlets.

5.18 Fused connection units shall be clearly labelled to show operation, and those feeding appliances via outlet hole and flexible cable or cord shall be complete with cable clamp.

5.19 Each connection unit shall be fitted with a cartridge fused to BS.1361 to suit the rating of the appliance controlled.

5.20 Switched fused connection units shall generally be mounted at 1800mm to underside of box with conduit and flexible outlet plate to a position adjacent appliance and complete with final connection. Unswitched connection units shall generally be mounted adjacent to appliance controlled, at 1800mm to underside of box, again complete with final connection via conduit and flexible outlet plate.

5.21 Double pole switches of either 20amp, 32 amp or 45 amp shall be complete with neon pilot light and generally be mounted at 1000mm to underside of box with conduits and flexible outlet plate to a position adjacent to the appliance and complete with final connection.

5.22 All electric water heaters, immersion heaters and shower heaters shall be installed on separate radial circuits unless otherwise directed and compliance with the Wiring Regulations will be strictly enforced. In particular, the requirements of the regulations in connection with special locations containing a bath tub or shower basin must be taken into account by the Contractor.

5.23 Switches generally for local control of water heating equipment shall be double pole with neon indicator and shall be mounted within 1800mm of the appliance.

5.24 Final connections to water heating equipment shall generally be in flexible cable in accordance with the previous clauses.

5.25 Shower heaters with back entry cable connection shall be fed via flexible cable from switch, unjointed through box behind. Care shall be taken to prevent the ingress of moisture into the heater and box.

5.26 Switches for shower heaters shall be double pole switched with neon and pull cord, ceiling mounted.

5.27 Cooker controls: the cooker switched shall be installed adjacent to the cooker position.

Cooker control switches may not be located over the cooker, or where they will be concealed, or where easy access is restricted by the cooker or other kitchen fitments.

The cooker switch is to be permanently engraved/labelled “COOKER”.

The oven and hob switches are to be permanently engraved/labelled with the appropriate wording.

A flush cooker connection unit is to be located 450mm above floor level, to one side of the rear of the cooker position. This unit is to be interconnected with the cooker switch by means of a concealed 10mm² [6mm²] PVC insulated and sheathed cable. The installer is to arrange for the final connection of the cooker using flexible cable, allowing 2000mm spare cable to facilitate movement of the appliance for cleaners.

5.28 The Contractor will be responsible for cutting out chases and flush accessory cut-outs. The Contractor will be responsible for making good all chases and flush accessory cut-outs in plastered walls and partitions.

6 TESTING AND COMMISSIONING

6.1 All accessories, switches and socket outlets shall be shown to function properly.

6.2 Testing of all accessories etc., shall be in accordance with current regulations and manufacturer’s instructions.

6.3 The Contractor shall ensure all accessories etc., are left in a clean and as-new condition at the completion of the contract.

6.4 All accessories shall be labelled as to their circuit reference. The labelling shall be to an agreed format with the Contract Administrator.

DIVISION 08 DISTRIBUTION BOARDS

1 SCOPE

1.1 The work shall comprise the provision of all the plant, labour and materials necessary to install distribution boards and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the contract.

1.2 The following details are applicable to distribution boards:

IP Rating	:	IP31
Cable Entry	:	Top/Bottom as applicable
Cable Exit	:	Top
Supply Characteristics	:	230/400 volt 4 wire 50Hz

1.3 Distribution boards are to be in the positions as indicated on the drawings.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. BS.88 & 1361 Cartridge Fuses

c. BSEN 60898 Miniature Circuit Breakers

d. BS.4293 Residual Current Circuit Breakers

e. BSEN 60439 HRC Fuses and Miniature Circuit Breaker Boards

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 Distribution boards shall be delivered to site suitably packaged to avoid damage to the paint finish. They shall be stored in a secure area protected from inclement weather and mechanical damage.

4 EQUIPMENT SELECTION

4.1 The distribution boards shall be of the miniature circuit breaker type as specified on the drawings and in this specification. All distribution boards shall use components manufactured by MEM Limited or to suit installed DB.

4.2 Fuseboards shall comply with BS.5486: PartII;1979 and shall be of the size and rating shown on the schematic drawings and be capable of accepting rated cartridge fuses to BS.88:1975 of the rating shown on the circuit charts.

4.3 Circuit breaker boards shall comply with BS.5486: Part12:1979 and shall be of the size and rating shown on the schematic drawings and be capable of accepting circuit breakers to BSEN 60898 of the rating shown on the circuit charts.

4.4 Distribution boards shall in all cases be provided with hinged lockable covers and are to be complete with integral isolators having a category of utilisation of AC22, unless specifically mentioned within the relevant division.

4.5 The hinged door shall be reversible for left or right-hand opening. Access to the cabling space and switchgear shall be obtained by removing a front cover, bolted with quarter turn fasteners. Ample cabling space shall be provided top and bottom for termination of the cables specified.

Removable blank gland plates shall be provided top and bottom.

4.6 The pan assembly shall be a completely independent unit which is removable. All components and sub-assemblies shall be mounted on a strong chassis consisting of at least 1.6mm thick zinc coated and passivated, folded sheet steel with an epoxy powder coated paint finish.

4.7 Busbars shall be made of hard drawn high conductivity copper. Busbars and associated connections are to be ASTA certified at 35kA for one second. Half rated neutral busbars shall be provided, each with a detachable link compliant with the current edition of the IEE Wiring Regulations. Busbar supports shall be designed to withstand maximum mechanical stresses under fault conditions. All busbars shall be fully shrouded.

4.8 Earth connector bars shall be provided in all distribution boards of a sufficient number of ways for the number of circuits plus one third spare capacity.

4.9 Distribution boards shall be provided with a separate neutral bar, having a separate way for each circuit, of each phase. The neutral bars are to be connected together with a copper strap by the distribution board manufacturer.

4.10 MCB distribution boards shall be of the DIN rail mounting type and shall offer a breaking capacity of 9kA:M9 to BSEN 60898 at 230/400v AC. If required, the outgoing circuit breaker shall be fitted with add-on leakage protection or ranges of add-on tripping or signaling devices as detailed on the circuit charts or drawings. This shall be possible either at installation or retrospectively with no special tools being required.

4.11 Sufficient miniature circuit breakers shall be provided for all ways of the distribution board excluding those designated as spare. Refer to the drawing for circuit details.

4.12 MCB's generally shall be fully tested to a minimum of 9kA:M9: Part 1 at 415V AC. all ratings of single -, two-, three-, and four pole MCB's shall meet this requirement.

All MCB's shall directly indicate the true position of the contacts from the handle and shall comply with the current edition of the IEE Wiring Regulations for isolation and switching.

MCB's shall be suitable for mounting in any DIN standard enclosure. Base mounting shall also be possible.

MCB's shall be capable of accepting a full range of accessories.

4.13 MCB Construction: the operation mechanism shall be mechanically trip-free from the operating handle, to prevent the contacts from being held closed against short circuit or overload conditions. The mechanism shall automatically reset.

The individual operating mechanism of each pole of a multipole MCB shall be directly linked within the MCB casing and not the operating handle.

The operating handle shall be of the toggle type, with facility for mounting a padlocking device.

Each pole shall be provided with a bi-metallic thermal element for overload protection and a magnetic element for short circuit protection.

Terminals shall be of the cage or tunnel type, to minimise the risk of human contact, and shall be capable of being tightened with both conventional and cross point screwdrivers. All screws shall be of the captive type.

MCB's shall be capable of accepting a full range of accessories, including earth leakage protection and remote tripping/indicating modules. It shall be possible to fit these accessories either during initial installation or retrospectively and shall not require the use of any special tools.

MCB's shall be capable of accepting a full range of shrouding accessories, including terminal shields and inter-phase barriers.

5 EQUIPMENT INSTALLATION

5.1 Distribution boards shall be fixed in positions as indicated on the tender drawing with due consideration for the future maintenance of the equipment. All distribution boards shall have 20% spare ways.

5.2 Boards shall be securely fixed in position by approved fixings.

5.3 Distribution board connections in conduit shall be made by means of a socket and male brass bush. All rough edges shall be removed.

5.4 Distribution board connections in trunking shall be suitably cut and the trunking connected using factory manufactured flanged plates. A suitable plastic or rubber trim shall be fitted to ensure that no cutting or chafing can occur.

5.5 If the distribution board casing requires hole cutting or drilling of any type, the switchgear back pan assembly will be removed whilst the work is carried out. Before refixing the back pan the board will be thoroughly cleaned and all swarfe and metal particles removed.

5.6 Circuit cables shall be arranged neatly within the distribution board casing. Excess lengths of cable will not be permitted.

5.7 Wiring connections to neutral and earth bars shall follow the same sequence, left to right or top to bottom.

5.8 Sample circuit lists shall be submitted to the Contract Administrator before the commencement of the installation of circuit charts.

6 LABELLING

6.1 Circuit lists shall be provided for each distribution board. The lists shall be typed and shall be firmly secured in a clear plastic wallet inside the cover of the distribution board. The ways on the boards shall be indicated in a clear and permanent manner.

6.2 Labels shall be fixed to the outside of distribution boards giving the designation of the board. Labels shall be of Ivorine or Traffolyte and shall be machine engraved with upper case letters not less than 6mm high. Letters are to be white on a black background. Labels shall be minimum 100mm long x 25mm high. The labels are to be fixed by brass screws, or other approved method.

6.3 The phases present at each distribution board shall be clearly indicated by the use of labelled identification discs.

7 TESTING

7.1 Testing shall be as specified in the current IEE Wiring Regulations.

DIVISION 14 INTERNAL LIGHTING

1 SCOPE AND SYSTEM DESCRIPTION

1.1 The work shall comprise the provision of all plant, labour and materials necessary to supply and install a complete lighting installation and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the Contract.

1.2 The scope is to provide a new LED energy efficient and controllable lighting installation to the new suspended ceilings as indicated on the drawings.

1.3 The lighting generally shall be by recessed LED 600 x 600 recessed panels including emergency lighting

1.4 Manual switches shall be provided for certain areas with the switch located at the doorway of the room. The rooms are the electrical cupboard switch-room.

1.5 Wiring shall generally consist of PVC insulated/PVC sheathed cables run within the fabric of the building.

1.6 LED exit lights shall be installed at emergency exit points.

1.7 All luminaires are to be installed to the Architects locations and reflected ceiling plans.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. BS.8206 Lighting for Buildings

c. IEC570 Electrical Supply Track Systems for Luminaires

d. IEC598 Luminaires

e. CIE29.2 Guide on Interior Lighting

f. CIE40 Calculations for Interior Lighting [Basic Method]

g. CIE52 Calculations for Interior Lighting [Applied Method]

h. CIBSE Code for Interior Lighting

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 All luminaires shall be delivered in properly protected packages and shall be in a secure store protected from damage and deterioration from atmospheric conditions.

3.2 Luminaires will be handled using protective gloves to prevent staining and damage to specular reflectors.

3.3 All materials and other equipment will be stored and handled in accordance with manufacturers instructions.

4 EQUIPMENT SELECTION AND SCHEDULES

4.1 Cable lengths shall be provided to allow future repositioning of luminaires. The cables shall be coiled up and cable tied together to give a neat installation.

4.2 Electrical accessories shall be from MK Limited finished in white pvc selected from the MK Logic Plus range. Plant rooms and stores shall be as Metalclad plus. External accessories shall be as the Masterseal range.

5. EQUIPMENT INSTALLATION

5.1 The Contractor shall allow for amending the manufacturer's terminal block in luminaires wired in cable greater than 1.5mm² for a terminal block that will accept the size of cable being used.

5.2 Luminaire fixing details a. to f. are detailed as the following:

5.3 When mounted directly upon the ceiling construction and wired via a loop in conduit system, shall be securely fixed to the conduit outlet box together with such additional fixings as are necessary. Wiring shall be taken directly into the terminal box within the luminaire.

5.4 Where fitted within false ceilings shall be supported from the false ceilings by means of the brackets and fixings provided by the light fitting manufacturer, to suit the particular type of false ceiling construction.

When mounted in false ceilings or bulkheads, the Contractor shall terminate the conduit and wiring system at a circuit conduit box outlet. From the ceiling outlet a 2 amp with a suitable length of 3 core 0.75mm² butyl rubber flexible cable to be used to give a final connection to the fittings. The 2 amp universal ceiling outlet shall be a maximum of 1 metre above the false ceiling.

5.5 Where installed where surface conduit has been used shall be securely fixed to the conduit system by means of conduit boxes forming part of the conduit system. Packing pieces will not be allowed, wiring shall be taken directly into the terminal box within the luminaire.

5.6 When mounted directly onto trunking shall be fixed by means of the special accessories provided by the trunking manufacturer. Wiring shall be taken directly into the terminal box within the luminaire.

5.7 Where specified, suspensions shall be by means of oval link cadmium plated chain conduit boxes and shall be fitted with domed hook ceiling plates for the chain suspensions. Luminaires shall be fitted with suitable spring loops or hooks.

5.8. When installed where recessed conduit has been used they shall be securely fixed to the conduit system by means of the manufacturers recommended fixings. Wiring shall be taken direct to the terminal box within the luminaire.

5.9 All luminaires to have at least 2 no. fixings.

6 TESTING AND COMMISSIONING

6.1 Testing shall be in accordance with current IEE Regulations.

6.2 All equipment shall be left by the Contractor in a thoroughly clean and as-new condition at the completion of the project.

DIVISION 15 GENERAL POWER

1 SCOPE AND SYSTEM DESCRIPTION

1.1 The work shall comprise the provision of all plant, labour and materials necessary to supply and install the power supplies for areas of the building, and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawing and this specification and subject to the conditions of the Contract

1.2 Wiring will generally consist of PVC insulated/PVC sheathed LSF cables installed within the fabric of the building creating a flush installation to all areas.

1.3 All new circuits for general purpose power outlets shall be wired on the ring main principle, no spur wiring shall be permitted. In general no more than 8-10 socket outlets are to be connected on one ring main.

1.4 Where power supplies are serving equipment, the flex shall be provided and connected by the Electrical Contractor.

1.5 All cleaners and general purpose power circuits are to be fed by 30mA RCBO's.

1.6 External sockets are to be as MK Electric Ltd selected from their Masterseal range c/w 30mA RCD provision as 56301 GRY for a single socket version.

2 PUBLICATIONS

a. The current IEE Wiring Regulations for Electrical Installations

b. BS546 Two pole and earth plugs and sockets

c. BS1363 13 amp plugs and socket outlets

d. BS3456 Safety of household appliances

e. BS4177 Cooker control units

f. BS8300 Disabled W.C Alarms

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 All equipment shall be delivered in properly protected packages and shall be kept in a secure store protected from damage and deterioration from atmospheric conditions.

3.2 All materials and other equipment will be stored and handled in accordance with manufacturer's instructions.

4 EQUIPMENT SELECTION AND SCHEDULES

4.1 To the units the finish of the accessories shall be white pvc finish and to suit part M requirements.

5 EQUIPMENT INSTALLATION

5.1 The electrical installation shall be mounted to suit DDA requirements and regulations.

5.2 The electrical installation in other areas where no ceilings are installed will provide a surface/exposed installation.

6 TESTING AND COMMISSIONING

6.1 Testing shall be in accordance with current IEE Regulations.

6.2 All equipment shall be left by the Sub Contractor in a thoroughly clean and as-new condition at the completion of the project.

DIVISION 17 FIRE DETECTION AND ALARMS

1 SCOPE

1.1 The work covered by this section of the specification comprises the provision of all the plant, labour and materials necessary to carry out the alteration to the fire alarm.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. BS.5445 and 5446 Components for Detection Systems

c. BS.5839 Fire Detection and Alarm Systems in Buildings

d. Fire Officer Committee Rules

e. Fire Brigade Regulations

f. Building Regulations

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 All fire alarm equipment shall be delivered in properly protected packages and shall be kept in a secure store protected from mechanical damage and deterioration from atmospheric variations.

4 EQUIPMENT SELECTION AND SCHEDULES

4.1 Alarm Bells – The sounder shall integral to each detector and shall be interlinked such that as one device is activated all the unit sounders operate.

4.2 The power supply to be a mains 230v supply to BS.5839 Pt 1 fed from the mains distribution in FP200 enhanced cable.

5 TESTING AND COMMISSIONING

5.1 On completion of the installation a complete test proving the correct operation of the system in accordance with the specification and drawings shall be carried out.

5.2 The installation shall, at completion, be given a certificate of approval.

5.3 The contractor shall provide fully detailed maintenance and testing literature.

5.4 During his commissioning the Electrical Contractor shall carry out the following;

a. Operate and prove each detection device.

b. Operate and prove sounders.

c. An audibility test and report of the findings.

A separate site visit shall be carried out to hand the system over to the agreed Client representative and to provide demonstration of how the system operates.

DIVISION 18 ELECTRICAL SERVICES IN CONNECTION WITH MECHANICAL SERVICES

1 SCOPE AND SYSTEM DESCRIPTION

1.1 The work shall comprise the provision of all plant, labour and materials necessary to maintain power supplies and control cabling required by the mechanical services installation, and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with this specification and subject to the conditions of the Contract.

1.2 In all areas the installation shall be a surface installation mounted on white PVC conduit & boxes..

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. Relevant Standards relating to materials detailed elsewhere in this specification.

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 Relevant material requirements detailed elsewhere in this specification.

3.2 Materials supplied as free issue items by other Contractors shall be kept in secure stores and protected from inclement weather and mechanical damage.

4 EQUIPMENT SELECTION

4.1 The Electrical Contractor shall allow for installing power supplies to the new mechanical equipment that shall include the supply/extract fan units, pumps and boilers. The installation shall be by the Mechanical Contractor. The fused connection units shall be complete with neon indicators. The control circuits for the extract fans are from local lighting circuits c/w run-on facility.

4.2 The Electrical Contractor shall provide and install all wiring from the equipment and shall work to approved drawings provided by the mechanical contractor.

5 TESTING AND COMMISSIONING

5.1 Control cables general: the Electrical Contractor shall be responsible for the termination and connection of all control cables installed by him unless specifically detailed.

4.2 The Electrical Contractor shall test and identify all cores of wiring before connecting.

4.3 The electrical installation shall be tested in accordance with current regulations.

6 Wiring Schedule

6.1 The following is a schedule of mechanical wiring that is to be allowed for by the Electrical Contractor:

a. Provision of power supply and control wiring to boiler in the kitchen.

b. Supplies to be single phase with local isolation and 3 core heat resisting flex. The local heating and HWS programmer to be mounted adjacent to the boilers.

c. Provision of power supply to the 2 low level heaters in the library.

d. Provision of power supply to the 3 high level heaters in the main hall.

e. Provision of power supply to the high level heater in the hall.

f. Provision of wiring to thermostat from heater in the hall.

g. Provision of power supply to the high level heater in the learning centre.

h. Provision of wiring to the thermostat from the heater in the learning centre.

DIVISION 25 EARTHING AND BONDING

1 SCOPE

1.1 The work shall comprise the provision of all plant, labour and materials necessary to install a complete earthing and bonding system and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the Contract.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. BS.951 Clamps for Earthing and Bonding

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 All earthing and bonding equipment shall be delivered in properly protected packages and shall be kept in a secure store protected from mechanical damage and deterioration from atmospheric variations.

4 EQUIPMENT SELECTION AND SCHEDULES

4.1 General: earthing and bonding shall be as detailed in the current edition of the Regulations for Electrical Installations.

4.2 Protective Conductors: the site of the protective conductor shall be related to the phase conductor [Smm²].

a. Where S is equal or less than 16mm² the protective conductor shall be equal to S.

b. Where S is greater than 16mm² and less or equal to 35mm² the protective conductor shall be 16mm².

c. Where S is greater than 35mm² the protective conductor to be half the phase conductor across sectional area.

The protective conductor shall be the same material as the phase conductor.

4.3 Earthing Conductor: the cross-sectional area of the earthing conductor shall be ascertained in the same manner as circuit protective conductors.

4.4 Main Equipotential Bonds: after the Consumers Earthing Terminal has been connected by the Supply Authority to their earth system, it shall be bonded to the metalwork of other services. This bonding connection shall be by means of copper bonding leads in accordance with the

requirements of the IEE Regulations and in the case of TNS Systems, and special requirements of the Supply Authority.

Connections to the pipework of other services shall be by means of purpose-made clamps.

The bonding connection shall be made as close as possible to the point of entry of the gas or water services into the building. The cross-sectional area of the main equipotential bonds shall not be less than half that of the earthing conductor subject to a minimum of 6mm². Except where PME conditions apply, the cross-sectional area need not exceed 25mm² if bonds are copper or equivalent to copper in conductance.

4.5 Supplementary bonding and circuit protective conductors shall be as required by the relevant regulations of the Requirements for Electrical Installations as published by the Institution of Electrical Engineers.

An efficient circuit protective conductor shall be provided throughout every part of every circuit of the installation.

Where the earth continuity conductor comprises a cable not forming part of a composite cable, no conductor smaller than 2.5mm² [7/0.67mm] shall be used. Such cables shall have copper conductor with yellow/green insulation of the same type as specified for the sub-circuit cables for that part of the installation [e.g. PVC, EPR etc].

Extraneous fixed metalwork in any room which contains a socket outlet shall be effectively bonded to the earth continuity conductor.

All metal sinks and tanks shall be directly and independently bonded to the circuit protective conductor.

All pipes entering or leaving water tanks shall be independently bonded together, so that effective bonding is maintained even if a steel tank is replaced with a tank of non-conducting material.

All structural steelwork which will remain accessible when the building is complete shall be bonded to the circuit protective conductor.

The metal framework of all equipment on which apparatus is mounted shall be bonded to the circuit protective conductor.

All radiators and exposed metal pipes shall be bonded to the circuit protective conductor, but where metal to metal joins existing and form continuous electrical circuit of negligible impedance, one bonding connection may serve for a group of radiators or pipework. However, in these circumstances at least one such bonding connection shall be made, on each floor level of the building, and at least one connection shall be made for every 200mm² of floor area served by the radiators and pipes.

Bonding connections to extraneous metalwork shall be made as unobtrusively as possible, connections to pipework being made in service ducts or voids when practicable. Such building connections shall not be made where pipes are buried, and to do so would render the connection inaccessible.

Wherever it is necessary for bonding connections to be made outside of service ducts or voids, the following methods shall be adopted:

a. Where the installation comprises insulated cables in conduit, bonding connections shall be made to extraneous metalwork where necessary, by extending the conduit system to a convenient point adjacent to the metalwork and terminating the conduit with a circular BS box containing an earthing terminal. A yellow/green insulated circuit protective conductor shall be taken from this point through a bushed hole in the lid to the box and bonded to the metalwork.

b. Where the installation comprises insulated and sheathed cables, bonding connections shall be made to extraneous metalwork where necessary by means of insulated and sheathed single core cables of the same type specified for these cables, from the nearest convenient earthing terminal on the system. Where the specification calls for insulated and sheathed cables to be protected by conduits, this shall apply also to such bonding connections.

c. Where the installation comprises mineral insulated metal sheathed cables, bonding connections shall be made to extraneous metalwork where necessary by installing a single core MICS cable of the type specified for the circuit wiring, terminating in a circular BS box with an earthing terminal at a convenient point adjacent to the metalwork. A yellow/green insulated circuit protective conductor shall be taken from this point, through a bushed hole in the lid of the box and bonded to the metalwork.

Excessive drilling of earth tapes or other operations which reduce the effective cross-sectional area of the tape shall not be permitted.

The ends of every circuit protective conductor, whether stranded or solid, shall be connected by an approved mechanical clamp.

All connections shall be accessible and made secure by screws of non-rusting material.

Where the conduit protective conductor is formed by metal conduit, trunking, ducts or metal sheaths of cables, all joints shall be mechanically sound and electrically continuous. For any part of a circuit the resistance of the earth continuity path shall be not more than twice that of the largest current carrying conductor of the circuit.

5 EQUIPMENT INSTALLATION

5.1 The system wiring shall be installed within conduits and trunking installed for heating and power systems and where applicable run in conduit installed for this system.

5.2 Final connections to certain items of equipment, where wiring leaves the conduit system, must be adjacent to the equipment and installed in a neat manner.

6 TESTING AND COMMISSIONING

6.1 Testing shall be in accordance with the current IEE Regulations for Electrical Installations.

DIVISION 28 SECURITY

1 SCOPE

1.1 The works shall comprise the provision of all plant, labour and materials necessary to revise the Security system for the new ceilings and the performance of such testing and commissioning as is prescribed to give an effective working installation in accordance with the drawings and this specification and subject to the conditions of the contract.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. The Equipment Manufacturers Handbook, Recommendations and Instructions

c. BS.4737 Intruder Alarms

d. NACOSS Requirements

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 The equipment shall be delivered and handled in such a manner as to prevent damage and be stored securely, all in accordance with the manufacturers recommendations.

4 EQUIPMENT SELECTION

4.1 The security system for the units only shall include containment, cabling and power supplies for intruder alarms and controls.

4.2 The security system equipment shall be supplied and installed by the security specialist. The Contractor shall allow in his tender for co-ordinating his works with the specialist contractor. The system shall comprise of an existing main security panel, door contacts and pir's to rooms with an external alarm sounder.

4.3 A front doorbell shall be provided with an internal bell sounder.

5 EQUIPMENT INSTALLATION

5.1 The Contractor shall provide conduit to provide wiring channels for the security and system specialist's use. The conduit system shall be installed as described elsewhere in this specification.

5.2 An unswitched fused spur outlet c/w neon indicator light shall be provided at the security panel position and intercom positions.

5.3 All conduits are to be left complete with draw wires for the specialist's use.

6 TESTING AND COMMISSIONING

6.1 The Contractor and security specialist shall allow for testing and commissioning the system in the presence of the client's staff and to the manufacturers specification. A completion certificate shall be provided in the manuals and handed over to the client. A maintenance agreement shall be offered to the client for the first year's maintenance (costs for this are not to be part of the tender)

DIVISION 29 TELECOM & DATA

1 SCOPE

1.1 The works shall comprise the provision of all the plant, labour and materials necessary to carry out the alterations & additions.

1.2 The system shall consist of cat 5E LSF cabling to each telecom outlet as shown on the drawings.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. The relevant standards relating to materials detailed elsewhere in this specification.

c. BS EN 41003 Connection to BT Networks

3 EQUIPMENT HANDLING BEFORE INSTALLATION

3.1 The equipment shall be delivered and handled in such a manner as to prevent damage and be stored securely, all in accordance with the manufacturers recommendations and as detailed elsewhere in this specification.

4 EQUIPMENT SELECTION

4.1 A data/telecom cabling installation c/w containment is to be provided.

5 EQUIPMENT INSTALLATION

5.1 The containment system shall be a system of conduits linked to the comms cabinet.

5.2 Back-boxes of a depth to suit cat 5E cabling shall be provided and installed by the electrical contractor with the faceplates provided and terminated by the data specialist.

5.3 The data specialist shall be employed by the electrical contractor with co-ordination of the trades under their control. The data specialist will liaise with the client and electrical contractor in all respects.

6 TESTING AND COMMISSIONING

6.1 The Contractor shall allow for testing the system in the presence of the Client's staff and to the manufacturer's specification.

DIVISION 33 ELECTRICAL TESTING

1 SCOPE

1.1 The work shall comprise the provision of all plant, labour and materials necessary to provide maintenance, inspection and testing procedures as is prescribed to give an effective working installation in accordance with the specification and subject to the conditions of the contract.

1.2 All new Circuits shall be fully tested and commissioned as detailed in this division.

2 PUBLICATIONS

a. The Current IEE Wiring Regulations for Electrical Installations

b. The British Standards

c. The National Inspection Council for Electrical Installation Contracting

d. The Electrical Contractors Association.

3 EQUIPMENT HANDLING BEFORE MAINTENANCE, INSPECTION AND TESTING

3.1 Testing procedures shall be carried out using certified instruments with current calibration certificates.

3.2 The Contractor shall ascertain any manufacturers special requirements for testing in accordance with Wiring Regulations. In particular, special care shall be taken with any equipment containing electronic components.

4 MAINTENANCE, INSPECTION and TESTING

4.1 General:

a. Standard methods of testing shall be used wherever possible but other methods are not precluded provided the results given are no less effective.

b. Periodic tests should be carried out in the sequence given in Section 6.

4.2 Safety:

The Contractor shall carry out methods of testing which shall be such that no danger to persons or property or damage to equipment can occur even if the circuit tested is defective.

Sequence of Tests

4.3 Inspection (Section 611)

The Contractor shall carry out an inspection of the electrical installation to verify that the electrical equipment is:

a. In compliance with the applicable Standards see section 511

b. correctly selected and erected in accordance with the current IEE Wiring Regulations for electrical Installations

c. not visibly damaged to impair safety

4.4 Testing (Section 612)

4.5 Before the supply is connected, or with supply disconnected as appropriate, the following items, where relevant, shall be tested by the Contractor in the sequence indicated:

a. Continuity of protective conductors, including main and supplementary equipotential bonding

b. Continuity of ring final circuit conductors.

c. Insulation resistance

d. Insulation of site build assemblies

e. Protection by SELV, PELV or by electrical separation

f. Protection by barriers or enclosures provided during erection

g. Insulation of non-conducting floors and walls

h. Polarity

i. Earth electrode resistance.

j. Protection by automatic disconnection of the supply.

4.6 With the electrical supply connected, re-check polarity before further testing using suitable test equipment.

a. Earth fault loop impedance

b. Operation of residual current devices.

c. Prospective fault current

d. Check of phase sequence.

e. Functional testing

f. Verification of voltage drop

4.7 Test Failure:

Any test failures shall be brought to the attention of the Contract Administrator for direction.

Should a failure to comply be indicated by any test, that test and those preceeding, the results of which may have been influenced by the fault indicated, shall be repeated after the fault has been rectified.

4.8 Certification:

The Contractor shall provide a completion certificate accompanied by the inspection and test certificates. Any defects or omissions revealed by the inspection and testing procedures shall be made good before the completion certificate is issued.

4.9 Attendance:

The Contractor shall ensure that the person responsible for the inspection and testing procedures shall be fully diversant, knowledgeable and competent in carrying out inspection and testing procedures.

The Contractor shall provide notice of when the inspection and testing procedures are to be carried out so that the Contract Administrator may be present and witness the tests being carried out.

4.10 Checking:

The Contractor shall make available any test equipment necessary so that the Contract Administrator may carry out random inspection and test checks of the electrical installation.

Including but not limited to :

a. Lux level meter
b. Residual current device tester
c. Audibility sound meter
d. Current measuring meter
e. Insulation resistance tester

4.11 Equipment: all test equipment shall be calibrated and copies of certificates submitted with test results.

4.12 Test results: shall be recorded on a form as attached at the end of this division of the specification.

5 TESTING PROCEDURES

5.1 Continuity of Protective Conductors

5.2 For cables having conductors of cross-sectional area not exceeding 35mm^2 their inductance can be ignored. Above that figure the inductance becomes significant and an appropriate a.c. instrument should be used for the measurement.

5.3 The test methods detailed below, as well as checking the continuity of the protective conductor, also measure (R_1 + R) which, when corrected for temperature, enables the designer to verify the calculated earth-fault loop impedance Zs.

Instrument – Use a low resistance ohmmeter for these tests.

Test Method

Strap the phase conductor to the protective conductor at the distribution switchboard so as to include all the circuit. Then test between phase and earth terminals at each outlet in the circuit. The measurement (R_1 + R) at the circuit's extremity should be recorded to verify compliance with the Wiring Regulations.

When testing of ring circuit continuity including protective conductors is required, the test should be made prior to connecting supplementary bonds to the protective conductors.

Test Methodology

Step 1 Connect one terminal of the continuity tester to one test lead and connect This to the consumer's earth terminal.

Step 2 Connect the other terminal of the continuity tester to another test lead

and use this to make contact with the protective conductors at various

points on the circuit, such as light fittings, switches, spur outlets etc.

The resistance reading obtained by the above method includes the resistance of the test leads. The resistance of the test leads should be measured and deducted from any resistance reading obtained using this method.

To test the bonding conductors continuity, use Test method

Notes

Where the alternative method of the Wiring Regulations has been used for sizing the protective conductor, it will be necessary to make a separate measurement of the protective conductor (R) using Test method.

It should also be recognised that these methods of test can only be applied simply to an 'all insulated' installation. Installations incorporating steel conduit, steel trunking, MICC and PVC/SWA cables will introduce parallel paths to protective conductors. Similarly, luminaires fitted in grid ceilings and suspended from steel structures in buildings will create parallel paths.

In this situation, unless a plug and socket arrangement has been incorporated in the lighting system by the designer, the (R_1 + R) test needs to be carried out prior to fixing accessories and bonding straps to the metal enclosures and finally connecting protective conductors to luminaires. Under these circumstances some of the requirements may have to be visually inspected after the test has been completed.

This consideration requires tests to be performed during the process of erecting an installation, in addition to tests at the completion stage.

Where ferrous enclosures have been used as the protective conductors, eg conduit, trunking, steel wire armouring etc., the following special procedure should be followed:

a) Perform the standard ohmmeter test using the appropriate test method described above.

Instrument: Use a low resistance ohmmeter for this test.

b) Inspect the enclosure along its length to verify its integrity.

c) If it is felt by the inspecting engineer that there may be grounds to question the soundness of this conductor, a further test should be performed using a phase-earth loop impedance tester.

Instrument: Use a loop impedance tester for this test.

d) If, following this further test, the inspecting engineer still feels that there may be grounds to question the soundness of this conductor, a further test may be performed using an ac ohmmeter which has a test voltage not exceeding 50v and can provide a test current approaching 1.5 times the design current of the circuit, excepting that it need not exceed 5A.

Instrument: Use a high-current low-impedance ohmmeter for this test.

Continuity of Ring Final Circuit Conductors

A test is required to verify the continuity of each conductor including the protective conductor, of every ring final circuit. The test results establish that the ring has not been interconnected. It may be possible, as an alternative, in order to establish that no interconnecting multiple loops have been made in a ring circuit, for the inspector to check visually each conductor throughout its entire length.

Instrument: Use a low-resistance ohmmeter for these tests.

Test Method

Each leg of the ring circuit is identified. The phase conductor of one leg and the neutral conductor of the other leg are temporarily bridged. The resistance is measured between the remaining phase and neutral conductors; a finite reading confirms that there is no open circuit on the ring conductors under test. These remaining conductors are then temporarily bridged together.

The resistance between phase and neutral contacts at each socket-outlet around the ring is measured and noted. The readings obtained should be substantially the same, provided that no multiple loops exist over the length of the ring.

Where the protective conductor is in the form of a ring, the test is repeated, transposing the circuit protective conductor with the phase conductors. The phase conductor from one leg of the ring is temporarily bridge with the circuit protective conductor of the other leg of the ring. The resistance is measured between the remaining phase conductor and the remaining unconnected circuit protective conductor at the origin of the circuit. A finite reading confirms that there is no open circuit on the ring conductors under test. The remaining circuit protective conductor and phase conductor are then temporarily bridged together.

The resistance is measured between the circuit protective conductor and phase conductor contacts at each socket outlet around the ring. The readings obtained should be substantially the same, provided that no multiple loops exist and the readings at the centre point of the ring are approximately equal to (R_1 + R) for the circuit. This value should be recorded and when corrected for temperature, may be used to calculate the earth fault loop impedance of the circuit Zs to verify compliance with the requirements of chapter 41 of the Wiring Regulations.

Note: Where single-core cables are used, special care should be taken to verify that the phase and neutral conductors of opposite ends of the ring circuit are bridged together. An error in this respect will be apparent from the readings taken at the socket outlets, progressively increasing in value as readings are taken towards the midpoint of the ring, then progressively decreasing towards the other end of the ring.

Insulation Resistance

These tests are to verify that for compliance with the Wiring Regulations the insulation of conductors and electrical accessories and equipment is satisfactory, and that electrical conductors or protective conductors are not short-circuited, or show a low insulation resistance (which would indicate defective insulation).

Before testing check that:

Pilot indicator lamps and capacitors are disconnected from circuits to avoid an inaccurate test value being obtained.

Voltage-sensitive electronic equipment such as dimmer switches, touch switches, delay timers, power controllers, electronic starters for fluorescent lamps etc., are disconnected so that they are not subjected to the test voltage.

There is no electrical connection between any live conductor and earth.

Note: The 17th Edition of the Wiring Regulations requires that, where equipment is disconnected for the purposes of the tests on the installation wiring and the equipment has exposed-conductive-parts required by the Regulations to be connected to the protective conductors, the insulation resistance between the exposed-conductive-parts and all live parts of the equipment shall be measured separately and shall comply with the requirements of the appropriate British Standard for the equipment. If there is no appropriate British Standard, the insulation resistance shall be tested at the appropriate test voltage specified in Table 61 of the 17th Edition of the Wiring Regulations and shall not be less than 0.5 megohm.

Instrument: Use an insulation resistance tester for these tests.

Insulation resistance tests should be carried out using the appropriate dc test voltage specified in Table 61 of the 17th Edition of the Wiring Regulations and the installation will be deemed to conform with the Regulations if each part as specified below has an insulation resistance not less than that specified in Table 61. Table 61 of the 17th Edition of the Wiring Regulations is reproduced as Table 1 below.

Simple installations that contain no distribution circuits should be tested as a whole.

The tests should be carried out with main switch off, all fuses in place, switches and circuit-breakers closed, lamps removed and other equipment disconnected. Where the removal of lamps and/or the disconnection of current-using equipment is impracticable, the local switches controlling such lamps and/or equipment should be open.

Table 1

Minimum value of insulation resistance

Circuit nominal voltage	Minimum Test Voltage d.c.	Insulation Resistance (Mohms)
SELV and PELV	250	0.5
Up to and including 500 V with the Exception of the above cases	500	1.0
Above 500 V	1000	1.0

WITHSTAND AND TEST IF REQUIRED 3750 a.c

N.B. Withstand tests may be called for in Standards. The figure of 3750 V is taken from Table 5 BS.3456: Part 101.

To perform the test in a complex installation it may need to be sub-divided into its component parts. The main panel is a separate component.

Although an insulation resistance value of not less than 0.5 megohms complies with the Regulations, where an insulation resistance of less than 2 megohms is recorded, the possibility of a latent defect exists. If this is the case, each circuit should be separately tested and its measured insulation resistance should be greater than 2 megohms.

Test Method

Insulation resistance between live conductors at appropriate switchboard.

Three-phase

Make a series of tests between live conductors in turn at the appropriate switchboard as follows:

Between phase 1 and phase, phase 3 and neutral grouped.

Between phase and phase 3 and neutral grouped.

Between phase 3 and neutral.

Where it is not possible to group conductors in this way, conductors may be tested singly. Resistance readings obtained should not be less than the minimum values referred to in Table 1.

Test Method

Insulation resistance.

Single-phase

Test between the phase and neutral conductors and earth at the appropriate switchboard.

Three-phase

Test between all conductors bunched with the neutral and earth. Where a very low reading is obtained, it may be necessary to separately test each conductor to earth.

Resistance readings obtained should not be less than the minimum values referred to in Table 1.

Where any circuits contain two-way switching, the two-way switches will require to be operated and any other insulation resistance test carried out, including the strapping wire which was not previously included in the test.

Site Applied Insulation

These tests are applicable only where insulation is applied during erection. They involve the use of high voltage and great care is necessary to avoid danger. The Health and Safety Executive's Guidance Booklet HS)G)13'Electrical Testing; safety in electrical testing' should be consulted.

When basic protection is afforded by insulation that has been applied to live parts of equipment during erection on site, a test should be made to check that the insulation is capable of withstanding an applied test voltage equivalent to that specified in the British Standard for similar factory-built equipment.

The test voltage is applied between the live conductors strapped together, and metallic foil wrapped closely around all surfaces of the insulation. The test voltage and duration must be in line with the appropriate British Standard specification.

Where there is no such British Standard, the test should be applied using a test voltage of 3750 V a.c. This test voltage should be at supply frequency and should be applied to the insulation for a duration of 1 minute. The insulation will be deemed to be satisfactory if no flashover breakdown occurs during the period of test.

Instrument: Use an applied voltage tester for this test.

Where fault protection is provided by supplementary insulation applied to equipment during erection, a test should be made to verify that:

a) The insulating enclosure affords a degree of protection not less than IPX. For details of test methods refer to Section 11 (Protection by barriers or enclosures)

b) The insulating enclosure is capable of withstanding, without breakdown of flashover, an applied test voltage equivalent to that specified in the British Standard for similar factory-built equipment.

The test voltage is applied between the live conductors strapped together, and metallic foil wrapped closely around all surfaces of the insulating enclosure. The test voltage and duration should be in line with the appropriate British Standard specification.

Where there is no such British Standard, the test should be applied to the insulation for a duration of 1 minute. The insulation will be deemed to be satisfactory if no flashover or breakdown occurs during the period of test.

Note: These tests involve the use of a high voltage and great care is necessary to avoid danger. The Health and Safety Executive's Guidance Booklet HS(G)13'Electrical Testing: safety in electrical testing' should be consulted.

Instrument: Use an applied voltage tester for this test.

Protection by Separation of Circuits

Functional extra low voltage

Part 6 of the Wiring Regulations does not require specific tests for SELV circuits but tests should be performed to confirm compliance with the Regulations.

The source of the supply should be inspected, and if necessary measured, to verify that the voltage does not exceed 50 V a.c. or 120 V d.c.

The means of basic protection should be verified. This may be by either:

a) Inspection of the barriers or enclosures to ensure a degree of protection not less than IPX or IP4X as appropriate, or

b) Except where the source is selected in accordance with Regulation 411-0-0, applying a 500 V d.c. insulation resistance test, the reading being taken after a period of 1 minute, between the live conductors of the SELV circuit and accessible insulation. The insulation resistance should be not less than 0.5 megohms. For sources selected in accordance with 411-0-0 the secondary circuit may be tested at 50 V d.c. and this insulation resistance should be not less than 0.5 megohm.

Instrument: Use an insulation resistance tester for this test.

If the insulation does not pass the 500 V d.c. insulation resistance test, accessible insulation should be reinforced so that it can withstand an applied voltage test of 1500 V a.c., applied for a duration of 1 minute without flashover or breakdown.

Instrument: Use an applied voltage tester for this test.

Fault protection is tested by checking continuity between any exposed-conductive-part of the SELV equipment and the non-earthed equipotential bonding conductor of the primary circuit.

Electrical separation

The source of supply should be inspected to confirm compliance with the Regulations. In addition, should any doubt exist, the voltage should be measured to verify it does not exceed 500 V.

Instrument: Use an insulation resistance tester for this test.

The live parts of the separated circuit must be tested to ensure that they are electrically separate from other circuits. This is achieved by testing between the live conductors of the separated circuit strapped together and the conductors of any other circuit strapped together.

The first test applied to this arrangement is an insulation resistance test at 500 d.c. The insulation resistance should be not less than 01.0 megohm.

Instrument: Use an insulation resistance tester for this test.

The second test is an applied voltage test at 3750 V a.c. at supply frequency for 1 minute. The test is deemed successful if no flashover or breakdown occurs.

Instrument: Use an applied voltage tester for this test.

The maximum short-circuit current should be determined to ensure adequate protection of the circuit against over current.

Instrument: Use an earth-fault loop impedance tester for this test.

A 500 V d.c. insulation resistance test is performed between the exposed-conductive-parts of any item of equipment connected, and the protective conductor or exposed-conductive-parts of any other circuit, to confirm compliance with the Regulations. The insulation resistance should not be less than 1.0 megohm.

Instrument: Use an insulation resistance tester for this test.

If the separated circuit supplies more than one item of equipment, the requirements of the Regulations shall be verified as follows:

a) Apply a continuity test between all exposed-conductive-parts of the separated circuit to ensure they are bonded together. This equipotential bonding is then subjected to a 500 V d.c. insulation resistance test between the protective conductor or exposed-conductive-parts of other circuits, or to extraneous-conductive-parts. The insulation resistance should not be less than 1.0 megohm.

Instrument: Use an insulation resistance tester for this test.

b) All socket outlets must be inspected to ensure that protective conductor contact is made to the equipotential bonding conductor.

c) All flexible cables other than those that feed Class II equipment must be inspected to ensure that they embody a protective conductor for use as an equipotential bonding conductor.

d) Operation of the protective device must be verified by measurement of the fault loop impedances to the various pieces of equipment connected, with reference to the type and rating of the protective device for the separate circuit. If protection is provided by over current devices, the appropriate value of loop impedance given in chapter 41 of the 17th Edition of the Wiring Regulations should be used.

Instrument: Use a loop impedance tester for this test.

Protection by Barriers or Enclosures

This test is not applicable to barriers or enclosures provided in factory-built equipment, but only to those provided on site during assembly or erection. Where during erection, an enclosure or barrier is provided, to afford basic protection a degree of protection not less than IPX is required. Readily accessible horizontal surfaces shall have a degree of protection equivalent to IP4X.

The degree of protection afforded by IPX is defined in BS.5490 as protection against the entry of 'Fingers or similar objects not exceeding 80mm in length. Solid objects exceeding 1mm in diameter'. The test is made with a metallic standard test finger.

Both joints of the finger may be bent through 90 degrees with respect to the axis of the finger, but in one and the same direction only. The finger is pushed without undue force (not more than 10 N) against any openings in the enclosure and, if it enters, it is placed in every possible position.

A low-voltage supply (of not less than 40 V and not exceeding 50 V for safety reasons) in series with a suitable lamp is connected between the test finger and the live parts inside the enclosure. Conducting parts covered only with varnish or paint or protected by oxidation or by a similar process, shall be covered with a metal foil electrically connected to those parts which are normally live in service.

The protection is satisfactory if the lamp does not light.

The degree of protection afforded by IP4X is defined in BS.5490 as protection against the entry of 'Wires or strips of thickness greater than 1.0mm, and solid objects exceeding 1.0mm in diameter'.

The test is made with a straight rigid steel wire of 1mm + 0.05/-0mm diameter applied with a force of 1N+10 percent. The end of the wire shall be free from burrs, and at right angles to its length.

The protection is satisfactory if the wire cannot enter the enclosure.

Note: Reference should be made to BS.5490 for a fuller description of the degrees of protection, details of the standard test finger and other aspects of the tests.

Insulation of Non-Conducting Floors and Walls

Where fault protection is provided by a non-conducting location the following should be verified:

a) Exposed-conductive-parts should be arranged so that under normal circumstances a person will not come into simultaneous contact with two exposed-conductive-parts or with an exposed-conductive part and any extraneous-conductive-part if these parts are liable to be at different potentials through failure of the basic insulation of a live part.

b) In the non-conducting location there shall be no protective conductor

c) Any socket outlets installed in a non-conducting location should not incorporate an earthing contact.

d) The resistance of insulating floors and walls to the main protective conductor of the installation should be tested at not less than three points on each relevant surface, one of which should not

be less than 1m and not more than 1 m from any extraneous-conductive-part, eg pipes, in the location.

If at any point the resistance is less than the specified value, the floors and walls are extraneous-conductive parts as detailed in the Regulations.

e) If any extraneous-conductive-part is insulated it should be tested and must be capable of withstanding at least 2kV r.m.s a.c. with breakdown and should not pass a leakage current exceeding 1mA in normal use.

Note: The following test involves the use of high voltage and adequate precautions should be taken to prevent danger. Consult HS(G)13.

Instrument: Use a high output applied voltage tester for this test.

Polarity

A test needs to be performed to check the polarity of all circuits. This can be done before connection to the supply, with either an ohmmeter or the continuity range of an insulation and continuity tester.

Instrument: Use a low-resistance ohmmeter for this test.

The method of test is the same as described for Test method 1 for checking the continuity of protective conductors.

For ring circuits, if the test required by Regulation 612.2.2 have been carried out, the correct connections of phase, neutral and c.p.c. conductors will have been verified and no further testing is required.

For radial circuits, the (R1 and R) measurements made in Test method should be made at each point then repeated with the phase and neutral strapped together at the distribution board, and the test made between the switch line and neutral strapped together at the distribution board, and the test made between the switch line and neutral at the light point, or phase to neutral at the equipment.

For lighting circuits it is necessary to check that all fuses and single-pole switches are connected to the phase conductor. The line connection in socket outlets and the centre contact of screw-type lamp holders must all be connected to the phase conductor.

Earth Fault Loop Impedance

The earth fault impedance Zs should be determined at the farthest point of each circuit including socket outlets, lighting points, sub-main cables and any other fixed equipment. The value obtained, after adjustment to take into account the effects of fault current, should not exceed that detailed in chapter 41, or should not exceed a value which might prevent conformity with the Regulations for r.c.d. protected circuits.

The earth fault current loop comprises the following parts, starting at the point of fault on the phase to earth loop:

a) Circuit protective conductor

b) The main earthing terminal and earthing conductors

c) For TN systems the metallic return path (or in the case of TT and IT system the earth return path)

d) The path through the earth and neutral point of the transformer

e) The transformer winding and the phase conductor from the transformer to the point of fault.

Test method to measure Ze.

Ze is measured using a phase earth loop impedance tester at the source of the installation supply.

The impedance measurement is made between the main phase supply and the main means of earthing with the main switch open or with all the circuits isolated. The means of earthing will be isolated from the installation earthed equipotential bonding for the duration of the test. Care should be taken to avoid any shock hazard to the testing personnel and other persons on the site whilst both establishing contact and performing the test.

Instrument: Use a loop impedance tester for this test.

Measurement of (R1 + R)

Whilst testing the continuity of protective conductors of radial circuits, or whilst testing the continuity of ring final circuits, a value of (R1 + R) will have been measured at ambient temperature.

The measured value of (R1 + R) for the final circuit should be added to the appropriate values of (R1 + R) for any distribution circuits.

An alternative means to determine (R1 + R) is to measure the loop impedance value at the extremity of the final circuit, taking care to use the correct phase supply and protective conductor return for the circuit. This loop impedance less the Ze value measured earlier can be taken as the value of (R1 + R).

These (R1 + R) values will be used to determine the value of Zs of the circuit under fault conditions, but must be first corrected for conductor temperature. This requires the use of correction factors dependent on the type of cable used in the circuit, and ambient temperature at the time of continuity testing.

Temperature Correction

The total (R1 + R) value must first be multiplied by a factor which is dependent on the ambient temperature at the time that the appropriate continuity test was performed. These correction factors for testing ambient temperatures other than 0°C are:

Ambient Temperature °C	Correction factor (Ca)
5	1.06
10	1.04
15	1.0
5	0.98

The resulting value in ohms must then be multiplied by a correction factor applicable to the type of cable insulation used on the circuit conductor, as this affects the maximum temperature of the cable in fault conditions. The multipliers are:

Insulation Material		85°C p.v.c.	90°C rubber	Thermosetting
	54B	1.30	1.4	1.48
Multiplier	54C	1.38	1.53	1.60

The multipliers are based on the simplified formula given in BS.6360 for both copper and aluminium conductors namely that the resistance-temperature coefficient is 0.004 per °C at 0°C.

54.2 applies where the protective conductor is not incorporated or bunched with cables, or for bare protective conductors in contact with cable covering.

54.3 applies where the protective conductor is a core in a cable or is bunched with cables.

This final value in ohms will now be added to the measured value of Ze, or if necessary to the declared value of Ze, to give the value for the circuit of Zs under fault conditions.

Alternatively, as a rule of thumb, the measured value of earth fault loop impedance of each circuit at the most remote outlet should not exceed two-thirds of the relevant values in chapter 41. If the measured value exceeds this comparative value, the reference test should be applied to identify the location of the high impedance.

Note: The normal method of test employed by a phase earth loop tester is to compare the unloaded loop circuit voltage with the circuit voltage when loaded with a low resistance, typically 10 ohms. This method of test can create an electric-shock hazard if the phase earth loop impedance is high and the test duration is not limited. In these circumstances the potential of the protective conductor could rise to phase voltage for the duration of the test.

Earth Electrode Resistance

After an earth electrode has been installed, it is necessary to verify that the resistance meets the conditions of the Wiring Regulations for TT and IT installations.

Instrument: Use an earth electrode resistance tester for this test.

Test Method

The test requires the use of two test spikes (electrodes) and is carried out in the following manner.

Connection to the earth electrode is made using terminals C1 and P1 of a four-terminal earth tester. To exclude the resistance of the test leads from the resistance reading, individual leads should be taken from these terminals and connected separately to the electrode. If the test lead resistance is significant, the two terminals may be short-circuited at the tester and connection made with a single test lead, the same being true if using a three-terminal tester.

The distance between the test spikes is important. If they are too close together, their resistance areas will overlap. In general, reliable results may be expected if the distance between the electrode under test and the current spike is at least ten times the maximum dimension of the electrode system, eg 30m for a 3m long electrode.

Three readings are taken: with the potential spike initially midway between the electrode and current spike, secondly at a position 10 percent of the electrode-to-current spike distance back towards the electrode, and finally at a position 10 percent of the distance towards the current spike.

By comparing the three readings, a percentage deviation can be determined. This is calculated by taking the average of the three readings from this average in ohms and expressing this as a percentage of the average.

The accuracy of the measurement using this technique is typically 1 times the percentage deviation of the readings. It is difficult to aim for a measurement accuracy better than 1 percent and inadvisable to accept readings that differ by more than 5 percent. To improve the accuracy of the measurement to acceptable levels, the test must be repeated with a larger separation between the electrode and the current spike.

The instrument output current may be a.c. or reversed d.c. to overcome electrolytic effects. Because these testers employ phase-sensitive detectors (p.s.d.), the errors associated with stray currents are eliminated.

The instrument should be capable of checking that the resistance of the temporary spikes used for testing are within the accuracy limits stated in the instrument specification. This may be achieved either by an indicator provided on the instrument, or the instrument should have a sufficiently high upper range to enable a discrete test to be performed on the spikes.

If the temporary spike resistance is too high, measures to reduce their resistance will be necessary, such as driving the spikes deeper into the ground or watering with brine to improve contact resistance.

Test method 2 (alternative for r.c.d. protected TT installations)

If the electrode under test is being used in conjunction with a residual current device protecting a TT installation, the following method of test may be applied as an alternative to the earth-electrode resistance test described above. This test method is relatively tolerant to inaccuracies in measurement.

Before this test is undertaken, any equipotential bonding should be removed from the earth electrode to ensure that all the test current passes through the earth electrode alone.

A loop impedance tester is connected between the phase conductor at the source of the TT installation and the earth electrode, and a test performed. The impedance reading is treated as the electrode resistance and is then added to the resistance of the protective conductor for the protected circuits. The product of this value in ohms and the residual operating current of the r.c.d. in amperes must not exceed 50 V.

If this value does exceed 50 V, Test method 1 should be employed to check the actual value of the electrode resistance.

AFTER THE TEST, ENSURE THAT EQUIPOTENTIAL BONDS ARE RECONNECTED.

Instrument: Use a loop-impedance tester for this test.

Test Results

The test results required will depend upon the application of the electrode and reference should be made to one or more of the following:

a) For TT and IT systems to comply with the disconnection times of the Regulations the product of the earth-electrode resistance and operating current of the protection device must not exceed 50 V.

b) When protection is afforded by a residual current device in an installation which is part of a TN or TT system, the product of the rated residual operating current in amperes and the earth fault loop impedance in ohms should not exceed 50 V.

c) With regard to higher resistance values British Standard 7430 Code of Practice for Earthing, suggests that values of electrode resistance of 200 ohms or above are prone to be unstable.