

RAND WATER

GENERAL ELECTRICAL SPECIFICATION

FOR THE

INSTALLATION OF ELECTRICAL PLANT AND EQUIPMENT

INDEX

1	INTRODUCTION	3
2	GENERAL SCOPE OF WORK	3
3	GENERAL CONDITIONS AND REGULATIONS	4
4	INSTALLATION OF EQUIPMENT AND MATERIALS - GENERAL	6
5	INSTALLATION OF EQUIPMENT	7
6	INSTALLATION OF ITEMS OF EQUIPMENT AND MATERIALS	8
7	LIGHTING AND SMALL POWER ELECTRICAL INSTALLATION	18
8	TESTING AND ENERGISING	22
9	COMMISSIONING	24

1 INTRODUCTION

This specification details the scope of work and equipment supply and states the practices and techniques to be adopted for the installation of the electrical equipment and shall be read in conjunction with the General Conditions of Contract and Special Conditions of Contract.

2 GENERAL SCOPE OF WORK

The scope of this specification is the supply of all plant, materials, tools, consumables, supervision, labour, transportation, technical and professional services necessary for the construction, installation, testing and commissioning of all electrical equipment as detailed within the body of this specification and attached drawings.

2.1 Scope of Work - General requirements

2.1.1 The Contractor shall acquaint himself with and follow the installation instructions in accordance with this contract.

2.1.2 All items of plant and material shall be new and recently manufactured from new material, completely assembled, installed and connected up in the locations shown on the contract drawings and shall be fully prepared for operation unless it is stated elsewhere that this work or part of this work is to be done by others. The Contractor shall include for functional testing of the completed installation.

2.1.3 "As Built" drawings

The Contractor shall supply a detailed record during the contract showing the "as built" condition of electrical equipment, cables etc. Surface run wiring need not be shown, but all buried cables/conduits are to be accurately shown. To assist the Contractor in compiling this record, Rand Water will supply one complete set of drawings for the express purpose of recording "as built" details during the progress of the contract. These drawings are to be kept clean and in good repair and are not to be used for construction purposes. The "as built" details are to be recorded in RED ink on site clearly, neatly and legibly in such a manner that a draughtsman will have no difficulty in transferring this information to the original drawings.

2.2 Scope of work - Inclusions

2.2.1 Furnishing and installing all required materials not specifically listed as supplied by Rand Water. All materials shall be as specified in Sections 4 and 5.

2.2.2 Complete installation of all items listed as supplied by Rand Water.

2.2.3 Connection of drive motors.

2.2.4 Receipt from Rand Water, inspection and reporting, custody, storage and all other handling required through to final installation of Rand Water supplied materials.

2.2.5 Supply, installation and connection of all terminations for wire and cable.

2.2.6 Fabrication and installation of all miscellaneous mounting brackets for electrical equipment, where required.

2.2.7 Pulling, anchoring and correct termination of all cable and wire, including the tagging of cables and connections.

2.2.8 Supply and installation of all electrical conduit and accessories.

- 2.2.9 Supply and installation of all above ground earthing conductors as shown on the drawings or as required by this specification or related codes, including all lugs and hardware and bolted and exothermic terminations.
- 2.2.10 Touch up painting and correction of any dents, burrs or other damage of electrical equipment installed by the Contractor and of structural steel, tanks, pipes etc, damaged during the installation of electrical equipment.
- 2.2.11 Excavation, placing cable, supply of and placing of protective covers/markers and backfill for direct buried cable.
- 2.2.12 Provision of supervision, qualified labour for the installation of plant and equipment and testing of the completed installation.
- 2.2.13 Supply and installation of holding down bolts drilled into concrete.
- 2.2.14 All items of plant shall be carefully levelled and adjusted for operation, providing all shims, packing or fixing/foundation bolts as required.
- 2.2.15 Items of plant shall be grouted in position prior to inspection and approval by the Engineer on the appropriate form. Grouting will be performed by the Civil Contractor but the Contractor shall be responsible for ensuring the equipment is satisfactorily grouted.
- 3 GENERAL CONDITIONS AND REGULATIONS
- 3.1 Regulations and Codes of Practice
- 3.2 All operations and work carried out on site shall conform to the latest recommendations and requirements, where applicable, of the following Regulations and Codes of Practice.
- 3.2.1 SABS 0142-1993 - Code of Practice for the Wiring of Premises.
- 3.2.2 Occupational Health and Safety Act (Act 85 of 1993).
- 3.2.3 In cases where SA Bureau of Standards Codes of Practice or Specifications are not available, then the relevant IEC or British Standard Code or Specification will apply.
- 3.2.4 The following standards shall apply for equipment and material supplied under this contract:
- | | | |
|---------------------|---|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| SABS 03 | - | Code of Practice for the protection of dwelling houses against lightning |
| SABS 151 | - | Fixed electric storage water heaters |
| SABS 1065 | - | Metal conduits and fittings |
| SABS 163 | - | Wall and appliance switches |
| SABS 164 | - | Plugs and socket outlets |
| SABS 1084 | - | Cover plates for wall outlet boxes |
| SABS 1085 | - | Wall outlet boxes for enclosure of electrical accessories |
| SABS 763 | - | Hot-dip (galvanised) zinc coatings |
| SABS 767 | - | Earth leakage protection units |
| SABS 970 | - | PVC conduit |
| SABS 1180 | - | Electrical distribution boards |
| SABS 1213 | - | Mechanical cable glands |
| SABS 1239 | - | Plugs, socket outlets and couplers intended for non-domestic use |
| SABS 1507 | - | Electric cables |
| SABS-IEC 439 Part 3 | - | Particular requirements for low voltage switchgear and control gear assemblies to be installed in locations where unskilled persons have access to their use including distribution boards |
| BS 5486 | - | Distribution boards for MCBs and MCCBs |
| IEC 947 | - | Low voltage switchgear and control gear |

- 3.2.5 Compliance with the latest amendments to the above codes, standards and specifications shall be a minimum requirement. In the event of different requirements between the codes and/or standards, the most stringent code shall apply.
- 3.2.6 Where conflict exists between any of the above regulations and the specifications, the said conflict shall be referred to the Engineer in writing for his ruling.
- 3.3 Site regulations - Introduction
- 3.3.1 The regulations described herein have been compiled to maintain safe working conditions at site and will be strictly enforced by Rand Water.
- 3.3.2 The Contractor will be held fully responsible for all aspects of site safety including those appertaining to any Subcontractor so appointed by the Contractor.
- 3.3.3 Regulations governing overtime worked shall be strictly adhered to.
- 3.4 Supervision and co-ordination of activities
- 3.4.1 All installation work shall be carried out under the supervision of the Contractor's site representative who shall have full charge of the work and who shall be thoroughly experienced and qualified in the erection and supervision of the work to be executed.
- 3.4.2 Workmanship shall be of the highest standard and its acceptability shall be at the absolute discretion of the Engineer.
- 3.4.3 The Contractor's site agent shall attend upon and supervise other Contractors where interests merge, for example with Civil Contractors when operations for electrical features are being undertaken and of Mechanical Contractors when testing of machinery is being undertaken.
- 3.4.4 The Contractor shall co-ordinate the electrical work with other Contractors, through the Engineer, to avoid undue interference, congestion and delays in construction.
- 3.4.5 The Contractor shall maintain an accurate detailed record of progress during construction, and shall report at the weekly site meetings.
- 3.4.6 The Contractor shall keep the area in which work is conducted both clean and tidy and shall undertake a weekly clean up.
- 3.5 General safety conditions
- 3.5.1 The Contractor shall at all times ensure that safe working conditions and procedures are strictly enforced in his working areas and also those of his Subcontractors.
- 3.5.2 The Contractor and his Subcontractors shall conform to any other regulations or instructions that may be promulgated from time to time.
- 3.6 Permit to work
- 3.6.1 Where connections are to be made to, or where work is to be performed on, an existing electrical system the Contractor shall not commence work until he has obtained written permission from the Engineer. The electrical supply shall not be restored without the written permission of the Engineer.
- 3.7 Explosive type fixing devices
- 3.7.1 Explosive type fixing devices shall be only used with the written permission of the Engineer.

- 3.8 Co-ordination and barricading of hazards
 - 3.8.1 All pits, trenches, temporary platforms, scaffolding or dangerous areas must be suitably railed off at all times in addition to the provision of adequate warning notices, lights and flag men wherever applicable.
 - 3.8.2 The Contractor must also ensure that no hazards or hindrances are inflicted upon other Contractors working in the same areas. Where such situations are unavoidable, prior notice must be given to the Engineer.
- 3.9 Fires
 - 3.9.1 Fires must not be lit in buildings, near inflammable materials, or within the area of the site.
- 4 INSTALLATION OF EQUIPMENT AND MATERIALS - GENERAL
 - 4.1 Workmanship
 - 4.1.1 All workmanship shall be good quality and all cutting, drilling, welding etc, shall be neatly done. The completed installation, including supports, brackets, wiring, cabling and conduiting shall present a clean compact appearance.
 - 4.1.2 Any section of the work or materials used which is considered to be unacceptable shall be remade or replaced to the satisfaction of the Engineer at the Contractor's cost for labour and materials. The Contractor shall, where applicable, install instruments and other equipment in accordance with the manufacturers' instructions and the standards and codes listed in Section 3.1 of this Specification.
 - 4.2 Changes in equipment position
 - 4.2.1 All equipment may be subject to localised changes of position during installation to suit the final equipment positions, building layout or operational requirements and claims for additional payments in respect of such work will not be accepted. The Contractor shall verify the positions of all items prior to the commencement of the installation and cabling of any item.
 - 4.3 Materials
 - 4.3.1 All apparatus, components, fittings and materials supplied and/or installed, whether expressly specified or not, shall conform in respect of quality, manufacture, tests and performance, with the requirements of the South African Bureau of Standards and/or the appropriate current IEC or British Standard Specifications and Addenda, excepting where otherwise specified or permitted by the Engineer in writing.
 - 4.3.2 The Contractor shall submit samples of all materials or equipment for approval by the Engineer before installation, unless prior approval has been obtained in writing from the Engineer. Such samples will be held for purposes of comparison with equipment and materials installed and will be released on satisfactory completion of the contract.
 - 4.4 Acceptance of work
 - 4.4.1 The Contractor is to seek early acceptance of work in reasonable small packages, to avoid undesirable practices being perpetuated, as the rectification of unsatisfactory work is costly in time and money.
 - 4.4.2 Acceptance of work eventually buried or concealed is to be sought at uncovered stages.
 - 4.4.3 At the completion of each package, the Contractor shall provide acceptance certificates for signature by the Engineer.
 - 4.4.4 Acceptance of packages shall be conditional upon the receipt by the Engineer of up to date "as built" drawings.

5 INSTALLATION OF EQUIPMENT

5.1 General

- 5.1.1 The Contractor shall acquaint himself with and follow any installation instructions provided with the project documents.
- 5.1.2 All accessories and equipment shall be completely assembled, installed and connected up in the locations shown on the project documents and shall be fully prepared for service. In all cases, accessories and equipment shall be installed (e.g. in the web of a stanchion) so that they are readily accessible yet protected from accidental impacts.
- 5.1.3 Equipment shall be mounted so as to be reasonably accessible for maintenance work and cleaning operations without the necessity of elaborate or precarious structures. This shall refer in particular to lighting fittings.
- 5.1.4 All equipment shall be carefully levelled and adjusted for operation.
- 5.1.5 Precautions shall be taken to counter vibrations likely to be transmitted by plant machinery. As vibrations are unlikely to be fully evident until machinery is operating, checks for vibration shall be made during commissioning. Any unsatisfactory conditions detected shall be reported in writing to the Engineer for remedial action.
- 5.1.6 Equipment shall not be grouted in position prior to inspection and approval by the Engineer.
- 5.1.7 Neither compressed air nor cotton waste shall be used for cleaning purposes.

5.2 Civil and builders work

- 5.2.1 Unless otherwise stated in the project drawings, all civil engineering works, including the cutting of holes through floors, walls or ceilings, the formation of pockets etc will be carried out by others.

5.3 Fixing

- 5.3.1 The prices quoted shall include for the design, supply, fabrication and installation of fixings for the mounting or holding down of all types of equipment such as racks, push button stations, switches, light fittings, distribution boards etc. The cost of rectifying any resulting damage to the building or structures shall be to the Contractor's account.
- 5.3.2 Brackets shall in general be made of mild steel flat bar, angle or channel, and before installation they shall be painted in accordance with Section 6.1.13 or galvanised in accordance with SABS 763. Except with the prior written consent of the Engineer, welding or drilling on vessels or piping is prohibited.
- 5.3.3 Under no circumstances will the burning of holes in structural steelwork be allowed.
- 5.3.4 The drilling of holes in structural steelwork of diameter greater than 7 mm will only be permitted with the written consent of the Engineer.
- 5.3.5 Brazing, cutting, welding etc, of any steelwork other than structural steelwork as a means of fastening or affixing any equipment shall only be permitted with the written consent of the Engineer.

5.4 Testing and Energising

- 5.4.1 Prior to being energised, all installations shall be tested as detailed in Section 8 (Testing and Energising) of this specification, and any defects revealed which are attributable to the Contractor shall be made good by the Contractor free of charge.

5.5 Painting and protective coating

5.5.1 Any miscellaneous steelwork supplied by the Contractor shall be painted in accordance with Clause 6.1.13 of this specification. The paint thickness shall be checked at site. Where paint work is damaged during erection by welding or by any other cause then remedial "touching up" to the original paint specification shall be carried out by the Contractor.

5.5.2 In certain cases it might be necessary to drill galvanised steelwork in order to fix support brackets. All such drill holes shall be treated with a cold-galvanising paint within 4 (four) hours of drilling. The type of cold-galvanising paint is subject to the approval of the Engineer.

6 INSTALLATION OF ITEMS OF EQUIPMENT AND MATERIALS

6.1 Cable racks and supports

6.1.1 General

- (a) Where called for in the project specification, the prices quoted in the schedules of rates shall include for the supply and delivery as well as the erection of the required rack or tray which shall include straight lengths, bends, elbows, tees, reducers, fixing brackets, fixing materials and touch up painting.
- (b) Approved ladder type cable racking will be Contractor furnished and constructed and supplied in accordance with Clauses 6.1.10 and 6.1.11 of this specification. The Contractor shall be responsible for the supply and installation of clamping, bolting, welding etc. arrangements to steelwork. The Contractor shall also be responsible for miscellaneous support steelwork etc, in areas where not steelwork is provided (these are generally near the termination of a route).
- (c) Welding of cable rack for securing purposes will, however, only be permitted with written consent of the Engineer.
- (d) Where welding is employed on butted sections a continuous seam weld shall be applied and touching up shall be to the original steelwork paint specification.

6.1.2 Obstruction

Cable racks shall be firmly installed in positions such as to cause as little obstruction to walkways etc, as possible.

6.1.3 Mounting

Cable racks are to be installed in the vertical plane unless otherwise indicated in the contract drawings or with written consent of the Engineer or his representative.

6.1.4 Rack covers

Racks located outdoors or passing through a floor level in an exposed location where mechanical protection of the cables is warranted, shall be provided with a solid painted or galvanised sheet metal cover. The cover shall extend at least 500 mm above the floor or ground level.

6.1.5 Single angle cable supports

Angle iron cable support galvanised or painted in accordance with section shall be Contractor supply and shall be used as indicated by the contract drawings and under the following conditions:

- (a) Up to, but no more than, 2 cables may be run on 1 angle iron.

- (b) The size of the angle iron shall be such that in cross section, no part of any cable shall project beyond the square of which the angle iron forms two sides.
- (c) The minimum size angle iron to be used shall be 25 x 25 x 3 mm.
- (d) Up to two angle iron runs may be used on the same route, but, if more than two angle iron sections are required, racking shall be used.

6.1.6 Supports

Cable racks or angles shall be secured to structures by rigid steel brackets such that there is no noticeable deflection of the rack/angle between support points.

The maximum distance between supports for cable racks or angles shall be:

- (a) Vertically mounted 1,5 m
- (b) Horizontally mounted 1,2 m

The rack shall be supported at every change in direction.

6.1.7 Bends

The radius of any bend shall not be less than the minimum bending radius for any cable on the rack or support.

6.1.8 Spare capacity

At final installation, all racks shall be no more than 66% (sixty-six per cent) full.

6.1.9 Galvanised racking

Galvanised racking shall be heavy duty construction with 50 mm or 76 mm sides and shall be of the ladder type. Only hot dipped galvanised (to SABS 763) sections will be acceptable, electroplated galvanised systems are not acceptable. Cable tray or light duty ladder racking is not acceptable except for the installation of instrumentation impulse lines.

6.1.10 Fabricated ladder type racking

The following angle iron sizes shall be used:

Racking up to 300 mm wide	:	25 mm x 25 mm x 4 mm
Racking >300 mm to 600 mm wide	:	40 mm x 40 mm x 6 mm
Racking >600 mm to 900 mm wide	:	50 mm x 50 mm x 6 mm
Racking >900 mm wide	:	75 mm x 75 mm x 6 mm

The flat bar rungs shall be 25 mm wide and the same thickness as the respective angle section. Alternatively top hat sections may be used.

6.1.11 Cable racking in chemically corrosive areas

For highly corrosive areas either stainless steel, aluminium, GRP or fibreglass ladder racking shall be used. The selection of the material shall be made in consultation with the Engineer. The Contractor shall obtain a ruling on the nature of the corrosive chemicals present prior to the commencement of the installation of the cable racking. Failure to do so may result in rejection of the cable racking.

6.1.12 Painting specification for fabricated cable racking

(a) Surface preparation

All oil, scale etc, shall be removed by means of shot or sand blasting to SA 2½ of Swedish Specification SIS 055900-1967 and thereafter pickled and zinc phosphated. No more than 12 (twelve) hours shall elapse between pickling and coating.

(a) Coating

(i) Primer

Paint type	:	Zinc phosphate
Thickness of coating	:	Min 5 micron
Application method	:	Zinc phosphate bath
Location	:	Shop
Maximum drying time/curing	:	24 (twenty-four) hours

(ii) Intermediate coat

Paint type	:	Epoxy powder
Trade name	:	Plascon Mobilox Fusion Bonded Pipecoating/PCL series or an approved equivalent of coating 150 to 250 microns
Application method	:	Fluidised bed or spray
Location	:	Shop
Maximum drying time/curing	:	Post cure may be required depending upon metal thickness

(iii) Final coat

Paint type	:	Modified epoxy amine powder
Trade name	:	Plascon Plastic Epoxy Repair Coating/EPR/1/3 or an approved equivalent
Thickness of coating	:	Final thickness 150/250 microns
Application method	:	Spray
Location	:	Shop or site
Maximum drying time/curing	:	48 (forty-eight) hours at 25°C
Colour	:	Black

6.2 Installation of cables

6.2.1 General

- Cables shall be stored in dry areas and handled correctly to ensure they are not damaged.
- After issue to the Contractor it will be the Contractor's responsibility to seal cable ends with PVC shrink caps for PILC, PVC or XLPE cables.
- Cable drums shall be rolled in the proper direction so as not to loosen or kink the cable. Unbattened cable drums shall not be rolled.
- It shall be the responsibility of the Contractor to measure the route length of the cable prior to cutting the cable. Cables shall be removed from their drums in accordance with this actual measured length required, and in such a manner that any surplus will be in the minimum number of separate lengths.
- The length of cables must be recorded when being pulled by a suitable measuring device approved by the Engineer.

- (f) Low voltage power and control cables may run on the same racks. A minimum of 300 mm shall be provided between cables carrying 50 Hz power and those carrying communication, digital and analogue instrumentation signals and where crossings occur they shall do so at right angles.
- (g) Where obstructions such as adjacent structures, pipes, drains etc, are encountered which necessitate diversions of cables then approval for such deviations shall be obtained from the Engineer prior to the installation of the racking and cables.
- (h) Where cables come out of the ground, a trench, or pass through a floor, they shall be protected by a metal pipe, or suitable mechanical protection, extending from 50 mm below to 500 mm above the exit point.
- (i) Only fully experienced and qualified personnel shall be employed for the termination and jointing cables for service in excess of 1000 volts. The Engineer reserves the right to make any examination or inspection considered necessary while the work is being carried out.
- (j) Cable bends shall be performed using the following minimum radii:
 - For 11 kV XLPE multicore cable : 15 times cable overall diameter
 - For 11 kV XLPE single core cable : 25 times cable overall diameter
 - For 11 kV PILC multicore cables : 12 times cable overall diameter
 - For 11 kV PILC single core cable : 20 times cable overall diameter
 - For PVC insulated power cables up to 50 mm² : 8 times cable overall diameter
 - For PVC insulated power cables over 50 mm² : 10 times cable overall diameter
- (k) All cables shall be laid neatly to avoid bunching and unnecessary cross-overs and all cable routes shall be planned in consultation with the Engineer.
- (l) All cable shall be drawn into the position using a sufficiency of rollers and cornering apparatus to avoid damaging the cable either by excessive bending or dragging.
- (m) Lighting cables shall be run wherever possible on power/control cable racking.
- (n) Medium voltage cables shall be run on separate racks to that of low voltage cables. The minimum spacing to communication and analogue cables shall be 500 mm and it is preferable that communication and analogue cables be routed on a completely different route to that of medium voltage cables.
- (o) Cables used for supervisory and PLC communication (optical fibre or twisted pair etc) will be unarmoured and within plant areas shall be run in galvanised conduit along their full length. The conduit shall be identified by means of a mauve stripe painted on the conduit at every change of direction and every 5 m along the conduit run.
- (p) The design of the conduit shall be such that optical fibre cable may be pulled into position without excessive stress being placed on the fibres.

6.2.2 Installation above ground

- (a) Installation on racks/trays

Cables are to be installed on racks or trays in a neat, orderly manner to enable the installation and replacement of any individual cable to be easily accomplished.

- (b) Cables shall be secured to supports using Bowthorpe-Hellerman cable ties or an approved equivalent. The cable ties shall be UV resistant. Medium voltage cable may be secured using bandit strap or preferably "U" clamps. If bandit strapping is used additional protection shall be applied to prevent damage to the outer sheath due to creepage. Cables shall be securely strapped to angle iron supports or cable racks at intervals not exceeding 500 mm and not more than two cables together.

- (c) Cable routes with a maximum of two cables may be supported using angle iron supports.

Alternatively cables may be supported in galvanised conduit of adequate size for the cable. If conduit is used it shall be mounted using hospital saddles and the end shall be reamed and bushed. Cables may not be secured directly to structures without any additional support systems.

6.2.3 Installation of cables in preformed trenches and ducts

- (a) Where cables are routed in preformed trenches they shall be secured on vertical cable racks fixed to the side walls of the trench.
- (b) Culverts or pipes will be installed under roads and other access ways, by others.
- (c) Not more than 2 layers of power cable shall be laid on the bottom of any trench/duct; cables grouped and supported along the sidewalls of trenches are preferred. The Contractor shall refer to the project drawings for actual requirements in this respect.

6.2.4 Installation of single core cables

- (a) Single core cables shall be installed in trefoil configuration using approved trefoil clamps. The Contractor shall supply samples of the proposed clamps for approval by the Engineer prior to the commencement of the installation of cables.
- (b) Medium voltage single core cables shall have the core screens connected at the source end only.
- (c) Where single core cables pass through barriers of magnetic metals the barriers shall be split to prevent the generation of circulating currents in the barrier.

6.2.5 Installation of cables in the ground

- (a) General

Requirements for cable trenching are detailed in Section 6.3 of this specification.

- (b) Prior to cable laying all sharp stones shall be removed and the trench bedded to a depth of 100 mm with fine stone free soil or river sand.
- (c) After installation of the cable, the cables shall be covered with a further 150 mm of fine, stonefree soil or sand.
- (d) Backfilling should only commence after permission to do so has been obtained from the Engineer. Backfilling, utilising dry material from alongside the trench, shall then be completed and the material should be tamped in layers of not more than 200 mm thick.
- (e) After the cables have been covered to within 300 mm of the surface a wide yellow PVC danger tape shall be laid continuously along the cable routes. The danger tape shall bear the words "Electrical Cable - Elektriese Kabel".

6.3 Cable trenches and road crossings

6.3.1 Excavation of cable trenches - Definitions

(a) Soft pickable materials

This shall mean material which can be removed by means of a pick and shovel.

(b) Hard material

This shall mean material which necessitates the use of mechanical equipment such as jack hammers for its removal. It shall include soft rock.

(c) Rock

This shall mean material which necessitates the use of blasting for its removal.

It shall be the responsibility of the Contractor to obtain from the Engineer a classification of material, in writing, during the excavation process and prior to backfilling.

Failure to do so will result in all material being classified as soft pickable material.

6.3.2 Cable trenching - General

- (a) The cable routes will be set out by the Engineer and the position of the intersection of any underground services will be pointed out on site by the Engineer. No excavation work shall start on any section of the trenches until that section of the route has been handed over to the Contractor by the Engineer. Excavation of the cable trenches shall be commenced as directed by the Engineer.
- (b) The Contractor shall provide, at his own cost, all means necessary for the protection of the roads, trenches, materials, and plant during the progress of the work and shall be solely responsible for securing, lighting and guarding all places dangerous to traffic, persons, animals or property and for all claims arising therefrom.
- (c) Excavation of trenches: Prior to carrying out excavation, the Contractor shall clear such areas of the site as are necessary for the proper execution of the work including storage and working areas of all vegetation, rubbish and all other objectionable material.
- (d) The cable trenches shall be excavated 800 mm deep for low voltage cables and 1 000 mm deep for medium voltage cables. The width of cable trenches shall be determined from relevant drawings or as instructed by the Engineer.
- (e) The Contractor shall maintain the correct line throughout the work and the trench bottom shall be graded so that no unreasonable gradients or abrupt changes in gradient occur.
- (f) All material excavated from the trench shall be kept within defined limits and deposited as directed by the Engineer. The toe of the spoil bank shall be trimmed well back from the edge of the trench so as to leave a minimum of 600 mm clear between the edge of the spoil bank and the edge of the trench.
- (g) The Contractor shall take every precaution to prevent water from any source entering the trench and entering buildings and structures from any excavation. The Engineer may order additional precautions to be taken where he is not satisfied with the Contractor's arrangements. The Contractor shall provide on site, adequate pumping equipment and any water, including seepage, entering the trench shall be removed immediately without cost to Rand Water.

- (h) If required by the Engineer, the Contractor shall leave unexcavated blocks in the trench to prevent the flow of storm water down the trench. These blocks shall be at least 1 m wide and shall be located as required.
- (i) The maintenance of all excavations in a safe condition, until, all the excavation work has been completed to the satisfaction of the Engineer, shall be solely the responsibility of the Contractor without cost to Rand Water. No undercutting of the sides of the excavations will be allowed.
- (j) After excavation the trench shall be maintained until the cable is laid. Should the sides collapse or any debris or water accumulate in the trench due to any cause, the trench shall be cleared and made good when so directed by the Engineer.
- (k) In paved areas cable trenches shall be capped with a 100 mm thick weak mix cement, positively coloured for identification purposes.
- (l) The Contractor shall remedy any settlement of cable trenches within a reasonable period after backfilling.
- (m) All precautions shall be taken to ensure that damage due to subsidence will not occur adjacent to roads, railways, walls, sewers, drains, pipes, concrete bases or similar structures.

6.3.3 Cable route marker beacons

- (a) The Contractor shall supply and install at every 50 m, at every change in direction, cable joint or road crossing a robust concrete cable route marker bearing a stainless steel or brass marker with the working "Electric Cable Route" with direction arrows engraved on it.
- (b) Communication cable routes shall have a permanent mauve stripe painted on the cable route marker.
- (c) The Contractor shall ensure that all cable routes are marked up correctly and comprehensively on the respective plant layout drawings.

6.3.4 Pipes used for road crossing

- (a) Pipes used for road crossings etc, shall be Kabelflex polyethylene corrugated tubing. All joints in the tubing shall be waterproof.
- (b) Alternatively the Contractor shall supply normal duty unplasticised PVC pipe to SABS 791; asbestos cement pipe to SABS 819; or concrete pipe to SABS 677. Metal pipes shall not be used.
- (c) All cable pipes shall be laid on a 100 mm layer of lightly rammed, fine, stone free soil placed on the bottom of the trench. The pipes shall then be covered by a 150 mm layer of fine, stone free soil before the trench is backfilled in the manner described in Section 6.2.5 above.
- (d) Cable sleeve pipes shall be of adequate length so that the sleeve pipes extend for a length of at least 1 000 mm each side of the road or other servitude.
- (e) The number and size of pipes shall be as indicated on the drawings. At the time of installation a 4 mm mild steel draw wire shall be installed in each pipe. After installation of the cables, all pipes shall be caulked to prevent the ingress of moisture and foreign material.

6.4 Cable and core labelling/identification

6.4.1 Cable labels

Every cable shall have a clear and durable label indicating the cable number at each end. In addition cable labelling shall be repeated every 25 m along its length, at every penetration and at every cable rack junction.

Bowthorpe Hellerman Deutsch Ovalgrip cable markers on arrow tags type AT2 with appropriate "Insulok" ties or an approved equivalent are required.

6.4.2 The cable number shall be allocated in accordance with the cable schedule.

6.4.3 In MCCs, control consoles and panels the cable numbers shall be permanently fixed to each cable end above the gland plate in a clear, visible position.

6.4.4 Cable core identification

All multicore cable cores having a reference other than R W B shall be fitted with Legrand type TAB 3, colour coded and numbered ferrules or equivalent corresponding to reference numbers shown on the cable schedules and interconnection diagrams.

Spare cable cores shall be numbered with an S followed by the cable number and shall be connected to spare terminals where these are available.

6.5 Cable terminations and cable joints

6.5.1 General

- (a) Only fully experienced personnel shall be employed for making-off cables for service in excess of 1 000 volts. The Engineer reserves the right to make any examination or inspection considered necessary while the work is being carried out.
- (b) The Contractor will at all times liaise with the Engineer to ensure that correct phasing is maintained throughout the installation.
- (c) Before any cable terminating work commences, the Contractor shall ensure that the respective cable is dead and that it will remain so for the duration of the work.
- (d) The Contractor shall ensure, from the commencement of work, that the cable dielectric is sound, by checking the insulation resistance and testing for moisture.
- (e) Where practicable, 1-2 m of slack should be left in medium voltage cables at terminations and joints.
- (f) The termination shall be made in a workmanlike manner, with particular attention to the cleanliness of tools, material, and working site. Paper and mineral insulated cable joints and terminations shall be completed swiftly and uninterruptedly once the sheath has been removed.
- (g) Paper insulated and XLPE medium voltage cables shall be made-off in -situ, and shall not be made-off and then moved into position.
- (h) Through joints in cables are prohibited unless the route lengths exceed the maximum drum lengths manufactured. When joints are necessary, they shall conform to the following:
 - (i) 600/1 000 V PVC, PVC, SWA, PVC grade cables "Jointmaster"/"Scotchcast"/"Cellpack" moulded case poured resin type.
 - (ii) Medium voltage PILC armoured cables "Scotchcast" pressure type.

(iii) Medium voltage XLPE - Raychem or Sigmaform heat shrink.

- (i) At terminations, cables shall be secured near the glands to prevent undue mechanical stress on the glands.
- (j) Where cable cores are connected to stud type terminals they shall be fitted with the correct size, hexagonal crimp, compression lug.
- (k) Termination of cables in switchgear, motor control centres, panels, starters etc, shall be done in a neat way, providing substantial supports so that the insulation of the cables is not stressed in any way.
- (l) Cable terminations at motors shall have a one turn loop of correct diameter between rack and terminal box to allow future reglanding of the cable.
- (m) Wiring shall be installed neatly, either saddled or strapped to the panel or supporting steelwork. Where this is not possible or practical, the cable loom shall be strapped together using one of the proprietary type plastic cable straps available for this purpose. Cotton insulation or thread shall not be used.
- (n) Tightening of harness saddles or straps must not result in:
 - excessive pressure being exerted, which would result in a reduction of the conductor insulation diameter
 - wear on the insulation
 - excessive tension
- (o) The tails of every cable shall be long enough that they can be readily disconnected for testing and such that any two may be interchanged for phase reversal.
- (p) Cable cores shall not be twisted together unless this is desirable for a design reason, i.e avoidance of pickup.
- (q) Conductors shall not be carried over or bent around sharp corners or edges.
- (r) Conductors passing through holes in chassis or screens shall be fully protected by correctly fitted grommets or bushes. Conductors carried across a hinged portion of a chassis or door shall be flexible. Sufficient slack shall be provided to ensure the conductors are not subjected to tension.
- (s) When stripping insulation from conductors, wires or strands must not be nicked or cut. A proprietary type of wire stripper must always be used. The stripping tool must be checked regularly and is subject to inspection by the Engineer.

No stranded conductors shall be fitted if any 1 strand has been damaged or broken. Wiring shall be arranged such that not more than two wires are connected to 1 side of each terminal.

6.5.2 Cable glands

- (a) All low voltage cables shall be terminated by means of approved shrouded glands (CCG, Pratley or equivalent) that offer adequate mechanical strength and earth continuity, they shall be weatherproof and comply with SABS 1213 - 1984.

Cable cores shall be neatly bunched and strapped to the Engineer's approval.

For each cable the core numbering sequence and colour codes shall remain standard throughout.

All stranded earth conductors shall be terminated by means of a crimped lug.

- (b) All terminations of XLPE and PILC cables shall be the appropriate RAYCHEM or SIGMAFORM kit. These terminations must utilise heat shrink stress control tubing and heat shrink anti-track tubing. In addition heat shrink insulating "boots" shall be applied over connecting points.

Anti-track tubing shall be easily distinguishable from other tubing by means of a colour other than black.

In the case of PILC cable "Rand Mines" type glands shall be fitted and gland cones shall be soldered to the armouring. Earthing tails shall be securely affixed between gland and earth bar to ensure correct earth bonding.

6.5.3 Cable lugs

- (a) All wires shall be terminated in crimped terminations of the appropriate type and size, and shall only be fixed using the proper hexagonal crimping tool as recommended by the maker of the termination. Bare wire terminations will not be accepted. Split type lugs are **not** acceptable.
- (b) Crimping tools for cables up to and including 16 mm may be hand powered types, but above 16 mm hexagonal die type hydraulic tools must be used.
- (c) It shall be the Contractor's responsibility to ensure that lugs, tools and dies are of the correct size for the cables.
- (d) Enlarging of holes in lugs is strictly forbidden.

6.5.4 Twisted pair and triad screened cables

- (a) At the commencement of the contract a sample termination shall be made for a screened cable and once approved by the Engineer all cables shall be terminated in the agreed manner. Failure to comply with this requirement may result in the rejection of all screened cable terminations.
- (b) All screened cables shall have the screens earthed at 1 end only. The other end of the cables shall have the screen insulated. Specific requirements for each cable will be shown on the instrumentation loop diagrams.
- (c) Each twisted pair or triad's screen shall be insulated with a heat shrink sleeve and the drain wire shall have a yellow heat shrink sleeve placed over it to insulate it from other wires and shall be terminated using a boot strap type crimping ferrule onto the earth terminal in accordance with the requirements of the loop diagrams.
- (d) Each end of the cables shall have the overall screen and wrapping cut back in a controlled manner and insulated with yellow heat shrink tubing. The overall screen drain wire shall be insulated and terminated as Item (c) above.
- (e) Each core shall be terminated using a boot strap type crimp ferrule and have numbering as specified above.

6.5.5 Drilling of gland holes/miscellaneous material

Tenderers shall include for the drilling of any gland holes required in gland plates and the supply of any packing, strapping, insulating tapes, putty or other materials necessary to complete the termination.

6.6 Junction boxes for control and lighting cables

6.6.1 General

- (a) All outgoing terminals shall be located so that all connections can be made easily.
- (b) The numbers of outgoing control circuit terminals shall be as shown on the relevant connection diagrams, including at least 10% (ten per cent) spare terminals.
- (c) Where bridging is required, 1,5 mm minimum yellow PVC insulated wire shall be installed.

6.6.2 Terminal boxes with up to and including 7 terminals

CCG or Pratley cable boxes shall be used.

Any unused ways to be fitted with blanking plugs.

6.6.3 Terminal boxes with more than 7 terminals

Junction boxes requiring more than 7 terminals shall be Klockner Moeller polycarbonate fully insulated pattern complete with rail mounted terminals.

6.7 Screwed metal conduit and metal trunking installation

6.7.1 General

- (a) Where electrical conduit is indicated on the contract drawings, this shall be heavy gauge, galvanised steel conduit and all fittings for surface installation shall be of the inspection type.

NOTE: Conduit with open seam is not acceptable.

- (b) All installations where screwed metal conduit and/or metal trunking are used shall comply with the SABS Regulations for the wiring of premises, SABS 0142-1993.
- (c) The minimum bending radius of conduit shall be 6 times the nominal conduit diameter.
- (d) All conduit joints and entries shall be screwed a minimum of 10 mm and made tight. Running joints shall be avoided.
- (e) Conduit ends shall be reamed after cutting.
- (f) Where equipment to be installed indoors is provided with a plain entry only, the conduit shall be fixed by means of a coupling and male bush and not by locknuts. For equipment installed outdoors or subject to moisture, rain tight hubs shall be used.

6.7.2 Wiring

- (a) Wiring is to be carried out by the "looping" method with joints being made at switches and fittings only. Approved mechanical connections may be used at these points but soldered and taped joints will not be permitted.
- (b) Lighting circuits may be bunched in the same conduit provided that the maximum allowable number of conductors is not exceeded and that no other type of circuit is run in the same conduit.

7 LIGHTING AND SMALL POWER ELECTRICAL INSTALLATION

7.1 Lighting and small power installation

7.1.1 General

The lighting and small power installation in all the plant areas shall be a PVC, PVC, SWA, PVC cable installation utilising industrial, heavy duty, weatherproof equipment and accessories.

The requirement for either "flush" or "surface" conduit installations (e g MCC rooms) will be defined on the relevant drawings.

7.1.2 220V Power socket outlets

Power socket outlets shall be Contractor supplied and unless indicated otherwise, shall be:

- (a) Installed so that the bottom of the unit is 1 100 mm above the finished floor level in plant areas and substations.
- (b) 450 mm above the finished floor level in control rooms and office areas.

7.1.3 Lighting Switches

- (a) Lighting switches shall be Contractor supplied and of the type and size indicated, and unless shown otherwise, shall be installed so that the bottom of the unit is 1 400 mm above finished floor level. The edge of any switch shall not be less than 150 mm from the outside edge or any door frame.
- (b) Where more than 1 switch on 1-phase is indicated at 1 position, a ganged unit shall be used. Where switches at 1 position are supplied from different phases, a phase barrier type box clearly labelled "DANGER 400 V" shall be used.
- (c) The arrangement of lighting switches in a ganged unit shall, where possible, correspond to the layout of the lighting points which they control.

7.1.4 Light fittings

All lighting fittings will supplied by Rand Water unless otherwise stated.

- (a) The location/mounting heights of fittings shall be as shown on the drawings. Any interference necessitating re-positioning of fittings shall be referred to the Engineer.
- (b) Ceiling suspended and wall mounted fittings shall be level and true, and rows of fittings shall be installed in straight lines. Fastenings and suspensions shall be such as to avoid any distortion which may be caused by handling during normal maintenance.
- (c) Fittings shall be positioned as shown on the relevant drawings.
- (d) Final cable connections to fittings shall in all cases be with CCG cable boxes and short lengths of PVC, SWA, PVC cables or heavy duty cabletyre. Looping through fittings will not be permitted. Cables shall be bottom or side entry only.

7.1.5 Lighting panels

Lighting panels will be supplied by the Contractor unless otherwise stated and shall be mounted where shown on the drawings so that the top of the panel is 1 830 mm above finished floor level.

7.1.6 Wiring

Unless otherwise indicated, the minimum size of conductor used shall be as follows:

Lighting	:	2,5 mm ²
220 V Socket outlets	:	4,0 mm ²

Wiring of conduit circuits shall be carried out using PVC insulated single core, 1 000 V general purpose cable. Phase and switch conductors shall be coloured red and neutral conductors black. In addition an earth wire shall be run continuously in each conduit route, irrespective of whether the conduit or fitting being fed is metallic or non-metallic.

7.2 Field mounted miscellaneous items

7.2.1 (Includes push button stations; conveyor-speed, side travel, pull wire switches; junction boxes etc.)

7.2.2 Where convenient the supporting brackets for these items may be attached onto existing steelwork, brickwork or concrete. After installation, all equipment shall be level, plumb and where applicable square to their respective surrounding. Push button stations or junction boxes shall be installed with the bottom edge 1 350 mm above finished floor level.

7.2.3 Limit switches operated by mechanical devices shall be carefully positioned and securely fixed to ensure consistent, efficient operation by the mechanical device. Cables to limit switches shall be given particular attention, to preclude damage by the operating device. Where practicable, limit switches and their cables

shall be readily removable.

7.2.4 Conveyor protective devices shall be installed to ensure correct safe operation.

7.2.5 All field mounted electrical equipment shall be protected with adequate corrosion resistant drip covers which shall be Contractor supply.

These covers must be approved in writing by the Engineer prior to installation.

7.3 Earthing

7.3.1 Earthing - Electrical system

(a) Substation main earth connections

The earth mat shall consist of a trench/rod earth which will be provided by others at the plant substations and MCC rooms. Earth resistivity measurements of the site and of any installed systems will be by others.

7.3.2 Earthing of electrical equipment

Notwithstanding anything to the contrary within the body of this specification and referenced specifications, electrical equipment shall be earthed as follows:

- by means of cable armouring
- by means of 2 x 70 mm² bare, stranded copper conductors between major electrical equipment, medium voltage, switchgear transformers, L T switchgear, motor control centres etc, and the earth bar
- by means of 16 mm² bare, stranded copper earth wire between equipment frames and a major earth wire for non specified items
- by means of the cable fourth core for cables up to 70 mm² and by means of a separate earth conductor of 70 mm² where larger cables are used
- by stainless steel bolts, nuts and washers

7.3.3 Cable racking

All cable racking shall have a 70 mm² bare stranded copper conductor run along its length for the attachment of the individual earths as above and which shall be connected at the substation end to the earth bar.

All racking shall be continuous and, where metallic, earthed. Where multiple racks are installed they shall be electrically bonded together at 10 m intervals.

7.3.4 Transformers

7.3.5 Transformers will be installed on concrete plinths provided by others.

7.3.6 Road access for the Contractor's cranes and trucks to the respective plinths will be provided by others.

7.3.7 Prices quoted in the schedule of rates shall include for loading at the site store, transport to the installation location, offloading at the plinths, and the preparation of silica gel breathers.

7.3.8 Before loading a transformer at the site store, the Contractor shall inspect the transformer and report any damage observed to the Engineer. The Contractor will be held responsible for damage not so reported.

7.4 Switchboards, control panels, distribution boards and motor control centres

This equipment shall be installed on existing steelwork, brickwork or concrete, and the prices quoted in

the schedule of pricing shall include for all support brackets, fixing/foundation bolts and the touch up of paint work.

7.4.1 The installation shall include:

- (a) The fabrication and installation of cable trench/duct to steelwork where required for trimming and cross bracing to support switchboards, distribution boards, and MCCs shall be included by the Contractor and shall be manufactured from 100 mm x 50 mm channel and 40 mm x 40 mm angle iron.
- (b) The fabrication and installation of 6 mm "Vastrap" plate covers for trenches/ducts where required.
- (c) Loading at the site store, transport to the installation location and offloading.
- (d) Alignment, levelling and fixing in position of the equipment.
- (e) All shims, packings and fixing/foundation bolts.
- (f) Bolting together of switchgear units using torque wrenches to manufacturers recommended torque settings.
- (g) Connecting through of all busbars and interconnecting control cabling.
- (h) On completion of assembly of equipment, a complete check that all nuts and bolts are tight, all connectors secure, that the equipment is free of foreign matter and that all barriers, covers etc, are in place.
- (i) The filling of equipment with insulating oil as necessary, from stock supplied by the Engineer.

7.4.2 All equipment shall be level and plumb after installation.

- (a) Distribution boards and control boards which are wall mounted shall have horizontal centre lines approximately 1 500 mm above floor level.
- (b) Mounting heights of all other equipment will depend on the circumstances but will also be subject to the approval of the Engineer.

- 7.4.3 Motor control centre connections and wiring shall be as follows:
- (a) Any permanent bridge wires on terminals in MCC cubicles or marshalling cubicles is to be carried out with 1,5 mm² YELLOW PVC insulated wire. Any interlocking within a particular MCC is to be carried out in the marshalling cubicle, where provided, in 1,5 mm² minimum BLUE PVC insulated wire. Details of this interlocking will be shown on the relevant schematic.
- 8 TESTING AND ENERGISING
- 8.1 General
- 8.1.1 Prior to being energised, all installations shall be tested as detailed hereafter, and any defects revealed which are attributable to the Contractor shall be made good by the Contractor.
- 8.1.2 Where defects in material supplied by Rand Water are revealed, these shall be reported to the Engineer.
- 8.1.3 No equipment other than 400/231 V lighting supplies shall be energised without the permission of the Engineer.
- 8.1.4 The Contractor shall be responsible nevertheless for the safety of both plant and personnel for the initial energisation of all plant and until the plant has been accepted by the Engineer.
- 8.2 Test equipment
- 8.2.1 The Contractor shall provide all tools and test equipment, including insulation testers, earth testers and ohmmeters, warning notices, lock out devices, protective barriers, radios etc, as required to carry out the tests described below.
- 8.2.2 Meters shall be made available by the Contractor on Site at all times for the use of the Engineer or his representative.
- 8.3 Tests on equipment exceeding 1 000 volts.
- 8.3.1 The Engineer will be responsible for directing the Contractor in the carrying out of tests on equipment required to operate at voltages exceeding 1 000 volts.
- 8.3.2 The Contractor shall make available suitable staff and testing equipment, including necessary AC and DC pressure test sets and current injection test sets.
- 8.3.3 Prices quoted in the schedule of rates shall also include for the stationing of guard personnel at the remote ends of H V cables undergoing tests.
- 8.4 Tests on equipment not exceeding 1 000 volts
- 8.4.1 General tests
- These shall include:
- (a) Verification of continuity, polarity and phase rotation.
 - (b) Determination of insulation resistance values between phases and between phases and earth.
 - (c) Determination of earth conductor loop impedance values to demonstrate that the conductivity of the earth conductors in accordance with the requirements of the SABS 0147.
 - (d) Proving correct mechanical operation of moving parts, e g relays, limit switches, switch or contactor mechanisms, timing devices etc.
 - (e) Proving correct operation of all mechanical, electrical or sequence interlocks.

8.4.2 Particular tests

(a) Low voltage cables (600/1 000 V)

All low voltage cables shall be tested for insulation resistance before installation and after termination (before connecting to apparatus) using a 1000 V D C insulation resistance tester. Insulation resistance values of less than 200 megohms before installation shall be suspect and investigated.

The end-to-end DC resistance of cores of buried cables shall be measured and recorded on the test certificates.

(a) Low voltage distribution switchgear and motor control gear

After erection, all low voltage distribution switchboards and motor control centres shall be tested for insulation resistance at 2 kV for 1 minute using a DC voltage pressure test set. Phase to phase and phase to earth insulation resistance values of under 50 megohms shall be suspect and investigated.

All motor protection devices shall be set at 100% (one hundred per cent) of motor full load current.

(b) Transformers

The 11 kV winding of transformers shall be tested to earth using a 5000 V DC insulation resistance tester and the L V winding using a 1 000 V DC insulation resistance tester. Insulation resistance values of under 500 mega-ohms and 200 mega-ohms for the H V and L V windings respectively shall be suspect and investigated.

Buchholz relays, if fitted, shall be tested by air injection. Temperature relays, if fitted, shall be tested by heating the probe in oil and checking operation of alarm and trip contacts

Silica gel breathers shall be oil sealed to the required level and checked for dryness.

(c) Field equipment

All field equipment shall be checked in respect of mechanical operation of all moving parts, tightness of connections etc.

(d) Operational tests

All control circuits shall be tested with live control busbars, for correct operation of control buttons, overloads, interlocks, trip switches, limit switches, prestart alarms, contractors, retaining circuits, indication lights etc.

If no other suitable power source is available, control busbars shall be energised by means of a petrol driven generator, provided by the Contractor during the operational tests.

Precautions shall be taken to ensure that the main busbars do not become energised during the testing operations.

8.4.3 Test certificates

All test results shall be recorded on test certificates which shall be submitted promptly (within 4 (four) days after the test dates) to the Engineer for his approval.

9 COMMISSIONING

- 9.1 The Contractor shall advise the Engineer, in writing, at least 7 (seven) days in advance of his readiness to commence commissioning to enable him to make the necessary arrangements for his representative to attend, if he so desires.
- 9.2 After satisfactory completion of all installation work and testing, the procedures for commissioning the plant shall commence as soon as possible.
- 9.3 The commissioning shall be done in the presence of the Engineer and shall start with a repeat of the operational tests, but in this case the control supplies shall be obtained from the control transformers in the switchgear.
- 9.4 After the repeat operational tests, the motors shall be tested for direction and then be put into operation.
- 9.5 The Contractor shall have sufficient staff available to remedy any defects which occur during the commissioning process.