PORTION 3

SPECIALIST WORKS

ELECTRICAL SPECIFICATION

TAFALOFEFE HOSPITAL: WATER AND WASTERWATER TREATMENT

Portion 3.1: Electrical Specification (**This document**)

Portion 3.2: Indoor Generator Set Specification

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E1 SPECIFIC CONTRACT SPECIFICATIONS

The General Conditions of Contract for Construction Works, 3rd Edition (2015), published by the South African Institution of Civil Engineering, is applicable to this development and the liability of the tenderer shall be governed by the aforementioned contract. The electrical works shall be carried out as a subcontract under the main contract.

E1.1 CONTRACTOR DESIGN AND OBLIGATIONS

The drawings included in this document represent a systems design defining the requirements of the Employer.

The Contractor shall be responsible for the workshop drawings and wiring diagrams required for the manufacturing and installation of motor control centres and instrumentation.

E1.2 QUALITY OF MATERIALS

Only materials of first-class quality shall be used and all materials shall be subject to the approval of the employer's agent prior to installation. Departmental specifications for various materials to be used on this contract such as department public works and infrastructure standard electrical specification (section A, B and C) are not attached but form part of this specification and available on the department website and from the employer's agent on request.

Wherever applicable the material is to comply with the relevant South African Bureau of Standards, department of public works and infrastructure electrical specifications which are available or to IEC Specifications, where no SANS specifications exist.

Materials wherever possible, must be of South African manufacture.

E1.3 TRAINING AND MAINTENANCE DURING DEFECT LIABILITY PERIOD

The Contractor shall inform the Engineer on the completion of the project and provide training to the person(s) responsible for the operation and maintenance of the project. The training shall be conducted for a period equivalent to 8 hours, starting with the basic information and getting into detail as time progresses. The training will be scattered into a minimum of 2 days. Training shall not be conducted unless materials and planned procedure is approved by the Engineer and the client representative. The number of personnel to attend the training shall be determined by the Client and contractor to ensure they all have training material as may be required.

During the defect liability period, the Contractor shall be responsible for the complete maintenance of equipment and plant according to the suppliers/manufacturer's specifications. Maintenance of the installation shall mean the regular servicing, lubrication, repairing, cleaning and adjustment of the installation as recommended by the manufacturers as well as the free of charge replacement of any defective components during this period.

A suitably qualified and trained person shall routinely and regularly examine and test the installation once every 3 months and shall also perform all the necessary maintenance tasks to ensure smooth and faultless operation. A quarterly report shall be submitted to the Engineer.

The Contractor shall immediately, on the day of first call-out, attend to breakdown/emergency calls. In the event of non-performance by the Contractor in this respect, the employer shall be entitled to make such other arrangements as are necessary, the cost of which shall be for the Contractor's account or deductible from any outstanding retention monies.

A logbook shall be kept and all servicing and repairs shall be recorded in this logbook with meticulous care. The logbook shall at all times be put at the disposal of the Engineer. The Contractor shall issue the logbook with full record of all services and repairs to the employer after the defect liability period has expired.

E1.4 OPERATION AND MAINTENANCE MANUALS

Three (3) sets of comprehensive operating instructions and maintenance procedures shall be provided on completion of the commissioning of the installation

One draft copy shall be submitted for scrutiny PRIOR to any commissioning.

E1.5 FIRE EXTINGUISHERS

Portable fire extinguishers containing liquefiable gaseous halons for Class S, B, C and E fires shall be installed in pump station and blower room. Areas with a room floor area not exceeding 50m² shall be equipped with a 2.5kg unit and rooms bigger than 50m² shall be equipped with a 4kg unit and equivalent mass of smaller units. In structures where more than one room is incorporated, housing different hazardous points, each room shall be equipped with appropriate extinguishers, e.g. a generator room with a separate fuel store.

Portable extinguisher shall comply with SANS 0105. Fire extinguishers shall be installed near exits or along exit routes in conspicuous and unobstructed positions and marked with conspicuous signboards. The extinguisher must be so installed that the carrying handle is 1.25m above floor.

Extinguishers that are to be mounted outside and adjacent to the main entrance door shall be mounted with a suitable cupboard.

E1.6 PLANNING AND PROGRAMING

The Contractor shall provide and maintain a detail construction program indicating duration of all manufacturing processes, transportation, delivery and installation dates.

There are no constraints on the execution of the work. However, any disruption of the normal working of the plant must be planned and co-ordinated in conjunction with the Engineer and Client

E1.7 SEQUENCE OF WORK

The electrical works shall be coordinated with the mechanical and civil works to ensure smooth execution.

E1.8 OTHER CONTRACTORS ON SITE

Should other contractors be required on site coordination between the concerned parties would be essential and this should not interfere with the works under this contract in any significant way.

E1.9 FORMAT OF COMMUNICATION

All verbal communication shall be confirmed in writing either by means of site instruction, letter or e-mail.

E1.10 KEY PERSONNEL

The electrical contractor shall have a registered installation electrician and he must have full control over all the electrical works as required by the OHS Act.

E2 ELECTRICAL SPECIFICATION

This part of the specification covers the electrical technical requirements of the new pump stations and blower room. Should there be any discrepancy between the Electrical General Technical Specification and the Electrical Particular Specification the latter shall have precedence.

E2.1 ELECTRICAL PARTICULAR SPECIFICATION

E2.1.1 MOTOR CONTROL CENTRE (MCC) CONSTRUCTION

Blower Motors (5.5kW)

Supply and install new MCC to control new 5.5kW blower motors which will start on variable speed drive with built in active front end rectifiers to reduce harmonics and it should fit in the existing 4x5m blower room with 3.4m clearance to the soffit of the concrete roof, the panel arrangement and controls shall be similar in general arrangement to drawings CAR18-1807E-001 and CAR18-1807E-002.

The MCC is to be manufactured from 3CR12 with a minimum thickness of 1.5mm. The MCC is to be light orange with smooth white back plates, finished from baked enamel with dry fil thickness of at least 0.1mm. Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough unbroken metal-phosphate film and then thoroughly dried. The paint shall have an impact resistance of 5,65 J on cold-rolled steel plate and a scratch resistance of 2kg.

The MCC shall be IP 54 rated and shall be specifically sized for the equipment for which it is to house. The MCC shall be designed in such a way that adequate heat dissipation is accomplished in order to prevent any de-rating of equipment or premature tripping of circuit breakers or any other electrical devices.

WTP Motors (50kW,10kW,5kW)

Supply and install new MCC to be housed in the new equipment building next to the existing raw water steel tank, proposed water treatment plant and new fire water tank, this MCC will control a local 3kW domestic booster pump motor, 50kW fire booster pump motor and provide electrical supply to the 10kW water treatment package plant (WTP) motor, the controls for WTP will be provided by the specialist however data should be extracted for transfer to the control room SCADA. The MCC should designed in similar general arrangement to drawing CAR18-1807E-001 and CAR18-1807E-002.

The MCC is to be manufactured from 3CR12 with a minimum thickness of 1.5mm. The MCC is to be light orange with smooth white back plates, finished from baked enamel with dry fil thickness of at least 0.1mm. Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough unbroken metal-phosphate film and then thoroughly dried. The paint shall have an impact resistance of 5,65 J on cold-rolled steel plate and a scratch resistance of 2kg.

The MCC shall be IP 54 rated and shall be specifically sized for the equipment for which it is to house. The MCC shall be designed in such a way that adequate heat dissipation is accomplished in order to prevent any de-rating of equipment or premature tripping of circuit breakers or any other electrical devices.

Submersible Motor (0.2kW)

Supply and install new MCC to be housed in the existing filter room opposite to the existing distribution board this will start on direct online starter and will control 0.2kW jockey pump motor.

The MCC is to be manufactured from 3CR12 with a minimum thickness of 1.5mm. The MCC is to be light orange with smooth white back plates, finished from baked enamel with dry fil thickness of at least 0.1mm. Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough unbroken metal-phosphate

film and then thoroughly dried. The paint shall have an impact resistance of 5,65 J on cold-rolled steel plate and a scratch resistance of 2kg.

The MCC shall be IP 54 rated and shall be specifically sized for the equipment for which it is to house. The MCC shall be designed in such a way that adequate heat dissipation is accomplished in order to prevent any de-rating of equipment or premature tripping of circuit breakers or any other electrical devices.

Variable Speed Drive (VSD)

All electrical motors including blower motor shall started using variable speed, only the submersible pump motor shall start using direct online starter. Each variable speed drive shall be rated at the rating of the motor and shall digital keypad and display screen with keys such as run, stop/reset, forward or reverse, hand, auto, and menu etc. It shall be designed to fit inside the MCC and shall have a built-in active front end rectifiers to reduce harmonics. It shall be rated at minimum input voltage of 230V phase to neutral and 400V phase to phase and shall have a minimum overload tolerance of 120% of rated current for at least 1 minutes every 5 minutes and a minimum 160% of rated current for 3 seconds during every 25 seconds.

E2.1.1.1 POWER COMPONENTS

All main incoming components such as isolators or circuit breakers shall accommodate a three-phase rotary isolator interlocked with the panel door, such that the door cannot be opened with the isolator or circuit breaker in the ON position.

E2.1.1.2 ELECTRONIC CONTROL EQUIPMENT

Any electronic component that is sensitive to electromagnetic interference shall be mounted in a location that prohibits such interference. Similarly, the mounting of components that emit heat shall be mounted in a position that does not interfere with other components operation.

The below equipment shall be mounted on the removable base plate in the MCC.

- Moulded Case Circuit Breaker
- Overload Relays
- Contactors
- Relays
- Low Voltage Power Supplies
- Variable Speed Drives
- RTU’s

E2.1.1.3 INDICATION LIGHTS

The MCC door for the corresponding starter shall accommodate its indicator lights.

The purpose of the indicator lights is to clearly indicate the following parameters from any place in the pump station.

- Pump running (green)
- Emergency stop pressed (yellow)
- Pump trip (red)
- Closed valve (white)

The lights shall be adequately sized / labelled and shall be clearly visible from any position in the pump station.

Samples of the indicator lights must be brought to site and tested prior to installation

E2.1.1.4 METERING

A digital multimeter shall from the main supply be able to display: current(A), power factor (PF), phase and line voltages(V), power(kW), apparent power (kVA), reactive power (kvar) and frequency.

Each running hour meter shall record and display the running hours of each pump either duty or standby.

E2.1.1.4 PUSHBUTTONS AND SELECTOR SWITCHES

All push buttons must be of the spring release type and colour coded and labelled as follows:

- Start (Green)
- Stop (Red)
- Reset (Black)
- Lamp test (Yellow)

A three-position selector switch must be positioned on each pump station panel door and labelled as follows:

- Position 1 (Manual)
- Position 2 (Off)
- Position 3 (Automatic)

E2.1.1.5 EMERGENCY STOP BUTTONS

An emergency stop push-button of the twist and release type must be positioned on the door of each motor starter for all motor control centres with an indication label.

Another emergency stop push-button of the twist and release type shall be mounted in close and visible proximity to the pump motor for each motor.

All emergency stop circuits **must be wired failsafe**.

E2.1.1.6 JUNCTION BOXES

Cable junction boxes shall be provided for connecting the integral power cables of any equipment (such as immersible or submersible pump motors) to the MCC via standard 4C cables or integral instrument cables such as transmitters or switches to instrument individual or multicore cables.

It shall furthermore be permissible to group instruments in a close proximity of each other together and connect their cables up to the PLC via a local marshalling junction box.

The junction boxes shall be manufactured from strong, impact and corrosion resistant materials and shall be IP68 rated and include adequately sized cable glands and screw terminals for proper termination of the cables.

The junction boxes shall be mounted in such positions that they are easily maintainable and not subject to damage during mechanical maintenance.

All cable glands shall be in accordance with the standard specification and shall furthermore be IP68 rated “enviro” type glands.

The contractor shall allow for all glands and junction boxes required for the installation in the prices submitted at tender.

All junction boxes shall be Pratley, unless stainless steel or aluminium boxes prove to be best suited for the application

E2.1.1.7 CONTROL PHILOSOPHY OF THE BLOWER UNITS (MCC)

New double blower units shall be installed in the blower room to form a duty/standby arrangement, which shall flip flop for each pumping cycle. The blowers will provide the required air based on oxygen demand and the detailed starting philosophy will be as detailed in civil engineer's specification.

Modes of operation

Blower units shall operate in three modes of operation 'AUTO', 'MAN' & 'OFF' and shall be available via a 3-position selector switch on the control starter panel door.

With the selector switch selected in 'AUTO' the control shall be as follows:

The blowers will automatically flip flop starting and stopping according to the conditions stated for :

- Starting blower units
- Stop blower units

All logic shall be performed by contractors, relays and timers etc

All fault and alarm conditions will need to be reset manually from the pump station when selected in 'AUTO'.

With the selector switch selected in MAN' the control shall be as follows:

In the manual selected position, the pumps shall be started manually by means of separate start and stop push buttons for each pump.

Manual operation is not to be the normal mode of operation and is only to be used for testing and maintenance purposes, therefore the operation shall be manned at all times during such operation with skilled and trained operators.

With the selector switch selected in 'OFF' the control shall be as follows:

No control shall be possible and any previously running equipment shall stop.

Pump & Motor Protection

The following pump and motor protection shall be available in the operational modes indicated in the table below:

TYPE OF PROTECTION	**AUTO**	**MAN**	**OFF**
Short circuit & overcurrent protection	×	×	
Earth fault protection	×	×	
Over & under voltage	×	×	
Phase sequence & imbalance	×	×	
Motor high temp	×	×	
Under load Protection	×	×	
Vibration	×	×	

Any fault condition that occurs must be indicated on remote SCADA and by an illuminated indication light and prevent any further operation of the motor until the reset push button has been pressed. Only once the fault has been cleared and the reset button pressed should the indication light go off and normal operation allowed commencing. All protection and float control circuits **must be wired failsafe.**

E2.1.1.7 CONTROL PHILOSOPHY OF THE WATER TREATMENT MOTORS

A pump-set shall be installed in the equipment building for domestic water pump booster on duty/standby arrangement, these shall alternate and one duty pump shall run to fill water into the elevated tank if the water level is regarded as empty, shall stop when the tank is regard as full.

Modes of operation

The pumps shall operate in three modes of operation 'AUTO', 'MAN' & 'OFF' and shall be available via a 3-position selector switch on the control starter panel door.

With the selector switch selected in 'AUTO' the control shall be as follows:

The pumps will automatically flip flop, starting and stopping according to the start and stop conditions as stated above.

All fault and alarm conditions will need to be reset manually from the pump station when selected in 'AUTO'.

With the selector switch selected in MAN' the control shall be as follows:

In the manual selected position, the pumps shall be started manually by means of separate start and stop push buttons for each pump.

Manual operation is not to be the normal mode of operation and is only to be used for testing and maintenance purposes, therefore the operation shall be manned at all times during such operation with skilled and trained operators.

With the selector switch selected in 'OFF' the control shall be as follows:

No control shall be possible and any previously running equipment shall stop.

Pump & Motor Protection

The following pump and motor protection shall be available in the operational modes indicated in the table below:

TYPE OF PROTECTION	**AUTO**	**MAN**	**OFF**
Short circuit & overcurrent protection	×	×	
Over & under voltage	×	×	
Phase sequence & imbalance	×	×	
Low & high level (float switch)	×	×	
Motor high temp	×	×	
Phase angle / Under load Protection	×	×	

Any fault condition that occurs must be indicated by an illuminated indication light and prevent any further operation of the pump until the reset push button has been pressed. Only once the fault has been cleared and the reset button pressed should the indication light go off and normal operation allowed commencing. All protection and float control circuits **must be wired failsafe.**

E2.1.2 DE-COMMISSIONING OF THE EXISTING PANELS

The existing pump-set and electrical equipment in filtration room is to remain in service until the new MCC and pump-set has been installed and commissioned for a trouble-free period of at least 1 week. Only once a trouble-free period of 1 week has been reported to the Engineer shall permission be granted to the contractor to proceed with the de-commissioning and upgrading of the existing pump-set. Should this not be a viable solution a new plan shall be established and presented to engineer for approval. The newly established plan shall ensure that the Hospital has enough water all times.

E2.1.3 LIGHTNING PROTECTION

All equipment in the control MCC shall be adequately protected against lightning and lightning induced disturbances on the control and power cables. Suitable lightning suppressors, surge arrestors and circuit breakers shall be provided to suit the particular application.

E2.1.4 GENERAL ELECTRICAL REQUIREMENTS

The Contractor shall refurbish the general electrical installation on site including all small power outlets and luminaries as shown on the drawings.

E2.1.5 LOW VOLTAGE (L.V.) CABLES AND TRENCHES

Supply and install the following L.V. cables. The cables shall comply with the requirements of SANS 1507 as amended. The cables shall be of the PVC/PVC/SWA/PVC type.

Source	To	With
Existing Eskom kiosk	LV room	120mm² x 4core Cu SWA PVC armoured copper cable with 120mm² bare earth
Existing LV room	Water Treatment MCC	70mm² x 4core Cu SWA PVC armoured copper cable with 70mm² bare earth
Existing LV room	Blower room	25mm² x 4core Cu SWA PVC armoured copper cable with 25mm² bare earth
Water Treatment MCC	Fire Booster Motor	50mm² x 4core Cu SWA PVC armoured copper cable with 50mm² bare earth
Water Treatment MCC	WTW panel	25mm² x 4core Cu SWA PVC armoured copper cable with 25mm² bare earth

E2.1.6 IDENTIFICATION OF CABLES

Cables shall be identified at all terminations by means of punched metallic bands or marked with labels or tags. (Refer also to SANS 10142). The use of PVC tape with punched characters is not acceptable. The identification numbers of cables shall be shown on "as built" drawings of the Installation.

E2.1.7 TRENCHING

General

The Contractor shall be responsible for all trenching excavations unless specified to the contrary.

The Contractor shall, before trenching commences, familiarise himself with the routes and site conditions and the procedure and order of doing the work shall be planned in conjunction with the general construction programme for other services and building requirements.

The Contractor shall acquaint himself with the position of all the existing services such as stormwater pipes, water mains, sewer mains, gas pipes, telephone cables, etc. before any excavations are commenced. For this purpose, he shall approach this Department's representative, the local municipal authority and any other authority which may be involved, in writing.

The Contractor will be held responsible for damage to any existing services brought to his attention by the relevant authorities and shall be responsible for the cost of repairs.

The Contractor shall take all the necessary precautions and provide the necessary warning signs and/or lights to ensure that the public and/or employees on site are not endangered.

The Contractor shall ensure that the excavations will not endanger existing structures, roads, railways, other site constructions or other property.

Mechanical Excavators

Power driven mechanical excavators may be used for trenching operations provided that they are not used in close proximity to other plant, services or other installations likely to be damaged by the use of such machinery.

The use of power-driven mechanical excavators shall be subject to the approval of the Department/Engineer. Should the excavator produce trenches that exceed the required dimensions, payment based on volumetric excavation rates will be calculated on the required dimensions only.

Routes

Trenches shall connect the points shown on the drawings in a straight line. Any deviations due to obstructions or existing services shall be approved by the Department/Engineer beforehand.

The Department/Engineer reserves the right to alter any cable route or portion thereof in advance of cable laying. Payment in respect of any additional or wasted work involved shall be at the documented rates.

The removal of obstructions along the cable routes shall be subject to the approval of the Department/Engineer.

Shoring and Waterlogging

The Contractor shall provide shoring for use in locations where there is a danger of the sides of the trench collapsing due to waterlogging or other ground conditions. Refer to the The Occupational Health and Safety Act.

The strength of shoring must be adequate for site conditions prevailing and the shoring must be braced across the trench.

The Contractor shall provide all pumps and equipment required to remove accumulated water from trenches. Water or any other liquid removed shall be disposed of without any nuisance or hazard.

Trenching

Trenching shall be programmed in advance and the approved programme shall not be departed from except with the consent of the Department/Engineer.

Trenches shall be as straight as possible and shall be excavated to the dimensions indicated in this specification.

The bottom of the trench shall be of smooth contour, and shall have no sharp dips or rises which may cause tensile forces in the cable during backfilling.

The excavated material shall be placed adjacent to each trench in such a manner as to prevent nuisance, interference or damage to adjacent drains, gateways, trenches, water furrows, other works, properties or traffic. Where this is not possible the excavated materials shall be removed from site and returned for backfilling on completion of cable laying.

Surplus material shall be removed from site and disposed of at the cost of the Contractor.

Trenches across roads, access ways or footpaths shall not be left open. If cables cannot be laid immediately the Contractor shall install temporary "bridges" or cover plates of sufficient strength to accommodate the traffic concerned.

In the event of damage to other services or structures during trenching operations the Contractor shall immediately notify the Department/Engineer and institute repairs.

Prior to cable laying the trench shall be inspected thoroughly and all objects likely to cause damage to the cables either during or after laying shall be removed.

Where ground conditions are likely to reduce maximum current carrying capacities of cables or where the cables are likely to be subjected to chemical or other damage or electrolytic action, the Department/Engineer shall be notified before installing the cables. The Department/Engineer will advise on the course of action to be taken.

Extreme care shall be taken not to disturb surveyor's pegs. These pegs shall not be covered with excavated material. If the surveyor's pegs are disturbed, they shall be replaced by a person qualified to do so.

Dimensions of trenches

Cable trenches for one or two cables shall not be less than 300 mm wide and need not be more than 450 mm wide. This dimension shall be valid for the total trench depth.

The width shall be increased where more cables are installed to allow for the spacings stipulated herein this specification.

Where trenches change direction or where cable slack is to be accommodated, the Contractor shall ensure that the requirements of the relevant SANS Specification regarding the bending radii of cables are met when determining trench widths.

Trench depths shall be determined in accordance with cable laying depths and bedding thickness.

Payment will be made on a volumetric excavation rate calculated on the basis of the given maximum dimensions or the actual dimensions, whichever is the lesser.

Joint Holes
Where cable joints are required to be made in the course of a cable run, a joint hole shall be excavated of sufficient size to enable the cable jointer to work efficiently and unimpeded.

Bedding

The bottom of the trench shall be filled across the full width with a 75mm layer of suitable soil sifted through a 6mm mesh and levelled off.

Only sandy clay or loam soil with a satisfactory thermal resistivity (not exceeding 1,5°C m/W) may be used for this purpose. Sea or river sand, ash, chalk, peat, clinker or clayey soil shall not be used. The use of crusher sand is acceptable.

Where no suitable soil is available on site, the Contractor shall import fill from elsewhere and make all the necessary arrangements to do so. The cost of importing soil for bedding purposes shall be included in the unit rates for excavations.

After cable laying a further layer of bedding shall be provided to extend to 75 mm above the cables.

The bedding under joints shall be fully consolidated to prevent subsequent settling.

Cable Sleeves

Where cables cross under roads, railway tracks, other service areas, etc. and where cables enter buildings, the cables shall be installed in Polyethylene (6mm thickness), asbestos cement pipes or earthenware pipes. Pitch fibre and PVC pipes are not acceptable because of the adhesion that occurs after a period of time between the pipe and the sheathing or outer serving of the cables.

Pipes shall be joined in accordance with the manufacturer's instructions.

Sleeves shall cross roads and railway tracks at right angles.

Sleeves shall have a minimum diameter of 100mm. They shall extend at least 2m beyond the tracks of a railway line or of the outermost tracks where there is more than one line. In the case of roads, the sleeves shall extend at least 1m beyond the road edge or kerb on both sides of the road.

All sleeves shall be graded 1:400 for water drainage.

Cable sleeves shall be installed to the spacings and depths stated herein.

Galvanised metallic sleeves up to and including 76mm dia. shall be supplied and installed by the contractor.

The ends of all sleeves shall be sealed with a non-hardening watertight compound after the installation of cables. All sleeves intended for future use shall likewise be sealed.

Backfilling

The Contractor shall not commence with the backfilling of trenches without prior notification to the Department/Engineer so that the cable installation may be inspected. Should the Contractor fail to give a timeous notification, the trenches shall be re-opened at the Contractor's cost. Such an inspection will not be unreasonably delayed.

For high voltage cables (1 kV to 11 kV) a coloured plastic marking tape shall be installed 400 mm above the cable. The tape shall be yellow, marked with the words "ELECTRIC CABLE/ELEKTRIESE KABEL" in red. These markings shall not be more than 1m apart from centre to centre.

Backfilling shall be undertaken with soil suitable to ensure settling without voids. The maximum allowable diameter of stones presents in the backfill material, is 75mm.

The Contractor shall have allowed in his tender for the importation of suitable backfill material if required.

The backfill shall be compacted in layers of 150mm and sufficient allowance shall be made for final settlement. The Contractor shall maintain the refilled trench at his expense for the duration of the contract. Surplus material shall be removed from site and suitably disposed of.

On completion, the surface shall be made good to match the surrounding area.

In the case of roadways or paved areas the excavations shall be consolidated to the original density of the surrounding material and the surface finish reinstated.

Cable Markers (for HV cables only, except where otherwise specified)

Cable markers shall be provided along all HV cable routes but need only be provided along LV cable routes where specified.

Cable markers shall consist of concrete blocks in the shape of truncated pyramids, approx. 300mm high, 150 x 150mm at the top and 250 x 250mm at the bottom.

Brass plates shall be cast into the tops of the blocks in such a manner that they cannot be prised loose. The wording "ELECTRIC CABLE/ELEKTRIESE KABEL" shall be stamped on the brass plates as well as direction arrows and the cable voltage rating.

Cable markers shall be installed on the surface along all the underground routes and shall project 35 mm above normal ground level unless the projected markers could be a hazard to pedestrian or other traffic in which case they shall be installed flush with the surface.

Cable markers shall be installed at the beginning and end of a cable run (e.g. where a cable enters a substation or building), at all changes of direction, above all joints, above cable pipe entries and exits and at intervals not exceeding 50 m along the cable route.

The position of cable markers shall be indicated on the "as built" drawings.

RAILWAY or Road Crossings

The Contractor shall not trench beneath any railway tracks without the TRANSNET Administration's supervision. The Contractor shall request the Department/Engineer timeously to arrange for the necessary supervision. The cost of such supervision will be paid for by the Department.

The Department/Engineer will arrange for the necessary wayleave and permission to cross TRANSNET property and railway tracks, or Provincial or National road reserves and TELKOM Authority approval of proposed cable routes.

The Contractor shall carry out the crossing installation in strict accordance with the TRANSNET and Provincial Administration's requirements and stipulations. Where these requirements are in contradiction with this specification, the Department/Engineer's ruling shall be sought.

The Contractor shall ensure that he will comply with the various Administration's requirements regarding crossing of Provincial and National roads, especially with regard to the safeguarding of the public. The Contractor shall also provide proof of adequate insurance cover against any claim from any accident as a result of work done by the Contractor during the crossing operation. The Department/Engineer shall also be indemnified from all liability in this regard.

The Contractor shall liaise with the various Administrations well in advance regarding the intended dates, times and expected duration of the crossing operations and obtain their approval of the programme and method of operation before commencing with the work.

E2.1.8 INSTALLATION OF UNDERGROUND CABLES

Installation Depths

Cables shall be installed at the following minimum depths below final ground level:

Up to 11kV : 600mm

All cable depth measurements shall be made to the top of the cable when laid directly in ground or to the top of the duct or sleeve where these are provided.

The above depths shall apply to the top layer where cables are installed in layers.

The Contractor may only deviate from the above depths provided prior authority in writing has been obtained from the Department/Engineer. In this event the cables shall be protected with a suitable concrete covering.

The depth of cable pipes or ducts beneath railway lines or roads shall be not less than 1,1 m below the formation level.

Cable Spacings

Cables installed in the same trench shall be laid parallel to each other with the following spacings between cables (LV: up to 1 kV; HV: 1 kV to 11 kV):

LV/LV	:	2 cable diameters
LV/HV	:	150mm minimum
HV/HV	:	150mm minimum
LV/HV/PILOT	:	1 cable diameter

Where HV and LV cables have to be installed in the same trench, both shall be laid at a depth of 800 mm and then covered with 200mm of soil. The soil shall then be compacted, and then backfilled layer by layer and compacted until the trench is completely backfilled.

Cables for telephones, communication systems and other low voltage systems (less than 50 V) shall be separated from power cables by at least 1m. All control or pilot cables without a lead sheath and steel armouring shall be laid at least 300mm from power cables.

Cables shall not be buried on top of each other unless layers are specified. The minimum spacing between layers shall be 200mm.

Cable Laying

Except where ducts, tunnels or pipes are provided, cables shall be laid directly in the ground.

The cable shall be removed from the drum in such a manner that the cable is not subjected to twisting or tension exceeding that stipulated by the cable manufacturer.

Cable rollers shall have no sharp projecting parts liable to damage the cables.

Where cables have to be drawn around corners, well-lubricated skid plates shall be used. The skid plates shall be securely fixed between Cable rollers shall be used as far as possible to run out cables. Rollers shall be spaced so that the length of cable in the trench will be totally suspended during the laying operation and sufficiently close to prevent undue sagging and the cable from touching the ground. Rollers shall also be placed in the trench in such a manner that they will not readily capsize.
rollers and shall constantly be examined during cable laying operations.Where cables have to be drawn through pipes or ducts, a suitable cable sock shall be used and particular care shall be exercised to avoid abrasion, elongation or distortion of any kind. In the case of oil filled cables, a cable sock may never be used. Special eyes giving access to the interior of the cable, must be utilised.

The maximum allowable tension when pulling a cable, is 70 N/mm² of conductor area.

It will be assumed that the price or rates contained in the tender includes for the installation of cables in pipes and ducts or below existing or newly installed services.

The Department/Engineer shall be informed timeously of the intention to carry out all cable laying operations to allow an inspection of the works by the Department/Engineer if so required.

E2.1.9 INSTALLATION OF CABLES IN CONCRETE TRENCHES

General

This paragraph covers the installation of cables in building trenches, service ducts, etc. The trenches, ducts, etc. inside buildings will be constructed and installed by others.

Installation

Cables shall be installed in one of the following ways:

(a) On horizontal cable trays.

(b) On horizontal metal supports with suitable clamps.

(c) On vertical cable trays or metal. supports fixed to the side of the trench. The cables shall be clamped in position.

Cables shall not be bunched and laid on the floor of the building trenches.

Covers

The covering of concrete trenches shall as a rule fall outside the scope of the electrical installation. The Contractor shall however be responsible for the cutting or drilling and smoothing of holes for cables through chequer plates, concrete or other coverings as required.

Cables shall enter and exit the trench through sleeves protruding 300mm beyond the covering. The sleeves shall be permanently secured in position and the open space between the cable and sleeves shall be sealed with a non-hardening, watertight compound.

Filled trenches

Where specified, floor trenches shall be filled with fine crusher sand (no river or see sand).

If a sand filling is specified, the cables shall be fixed to non-corroding supports.

Sand-filled trenches other than in substations shall be covered in one of the following ways:

(a) Reinforced concrete covers.

(b) Sand and cement screed.

(d) Removable chequer plates.

Method (a) above shall be used where vehicular traffic may be encountered over trenches. Unless otherwise specified allowance for a mass of 2 tons shall be made.

Cable trenches in substations, switch rooms and generator rooms shall be covered in accordance with the specification.

E2.1.10 FIXING OF CABLES TO TRAYS OR STRUCTURES

Installation

Cables may be installed in one of the following ways:

- On horizontal cable trays.
- Against vertical cable trays with suitable clamps.
- Against horizontal or vertical metal supports or brackets with suitable clamps.
- On clamps which are fixed to the structure.

Clamps

Suitable clamps (cleats) which will secure cables without damage shall be used. Metal clamps or drilled hard wood blocks shall be used. Clamps shall consist of adjustable metal wings which clamp to a metal support, or consist of two halves that are bolted together. The correct clamp size to fit the cable shall be used. Cables of different sizes may only be fixed by a common clamp when the clamp is specially made to accommodate the various cables.

E2.1.11 GROUPING AND SPACING OF CABLES IN BUILDINGS AND STRUCTURES

Spacing correction factors

Cables shall as a rule be spaced two cable diameters apart, for which no grouping correction factor need be applied.

Cables on Different Levels

Where parallel cable runs are installed at different levels (e.g. on parallel cable trays) and where the spacing of the layers is not specified, a minimum spacing of 300mm shall be maintained.

Single Core Cables

Where single core cables are installed along a three-phase circuit, the cables shall be installed in trefoil formation and bound together at 300mm intervals.

High Voltage Cables

High voltage cables shall be separated from other cables and services throughout the installation and shall as far as possible be installed in separate floor trenches, pipes or metal channels. Where this is not feasible a minimum spacing of 500 mm shall be maintained.

Cables for Other Services

Cables for telephones, communication systems and other low voltage systems (less than 50 V) shall be separated from power cables. In building ducts a physical barrier shall be provided between power cables and cables for other services. Where armoured cables are used for such other services, they shall be installed on separate cable trays or shall otherwise be at least 1m away from power cables. Where unarmoured cables are used for these other services, they shall be installed in separate conduits or metal channels.

E2.1.12 TERMINATION AND JOINTING OF CABLES

General

Cable ends shall be terminated with glands or in cable boxes with the associated accessories such as clamps, shrouds, etc. complying in all respects with the specification.

Connection of cables to switchgear shall always be effected in such a way that the various phases, seen from the front of the switchgear will be in the following positions:

- No. 1 conductor : left (red) (A)
- No. 2 conductor : centre (white) (B)

- No. 3 conductor : right (blue) (C)

Exposed armouring shall be covered with bitumen-base paint.

All cable ends shall be supplied with the necessary earth connection.

A channel or other approved means of support shall be provided to remove mechanical stress from the glands. Cable cores shall be marked with heat-shrunk sleeves where necessary to identify the phases. Refer to SANS 10142.The current-carrying capacity and breakdown voltage of the cable end shall be the same as for the complete cable.

Termination of PVC-insulated Cables

Cable ends shall be terminated by means of adjustable glands and the glands shall be fitted in accordance with the cable and gland manufacturer’s instructions.

The correct size and type of gland shall be used for the particular cable and application.

Connection of Cable Conductors

Suitable lugs shall be used, preferably solidly sweated to the cable conductor ends. Lugs may be crimped, using mechanical or pneumatic tools designed for this purpose, on condition that evidence is submitted that the method used complies with the performance requirements of BS 4579, Part 1 : "COMPRESSION JOINTS IN COPPER".

Contact surfaces shall be thoroughly cleaned and smoothed and fixing bolts shall match the hole size of the lug.

Cables that are connected to clamp type terminals where the clamping screws are not in direct contact with the conductor, need not be lugged but the correct terminal size shall be used.

Ferrules shall be used as far as possible where cable conductors are connected directly to equipment with screws against the conductor strands.

When cutting away insulation from cable conductors to fit into lugs, care shall be taken that no strands are left exposed. Under no circumstances may any of the conductor strands be cut away to fit into lugs.

Joints

Joints in cable runs will not be allowed unless specified in the Detail Technical Specification or authorised by the Department/Engineer.

Jointing shall be carried out strictly in accordance with the manufacturer's instructions and by personnel competent in jointing the types of cables used.

During outdoor jointing operations, the joint bays shall be adequately covered by tents of waterproof material suitably supported. Where necessary a trench shall be excavated around the bay to prevent the ingress of moisture. The sides of the hole shall be draped with small tarpaulin or plastic sheeting to prevent loose earth from falling in during jointing operations.

The joint shall not impair the anti-electrolysis characteristics of the cable.

The Contractor shall notify the Department/Engineer timeously of the day on which jointing is to be carried out in order than an inspection may be arranged if so required. Any cable joint not inspected by the Department/Engineer because of insufficient notice being given, shall be opened for inspection and redone at the discretion of the Department/Engineer at the cost of the contractor.

LV cable joints shall be of the epoxy-resin type. Joints shall be fully water and air tight and shall be free of voids and air pockets.

The crossing of cores in joints will not be permitted under any circumstances.

E2.1.13 TESTING

Each cable shall be tested after installation in accordance SANS 1507 (up to 1 kV) and SANS 97 (up to 11 kV) as well as the requirements of the Local and Supply Authorities.

LV Cables shall be tested by means of a suitable megger at 1 kV and the insulation resistance shall be tabulated and certified.

The Contractor shall make all arrangements, pay all fees and provide all equipment for these tests. The cost of testing shall have been included in the tender price.

The Contractor shall notify the Department/Engineer timeously so that a representative of the Department may witness the tests.

On completion of the tests on any cable, the Contractor shall without delay, submit three copies of the certified Test Reports to the Department/Engineer.

E2.1.14 MEASUREMENT AND PAYMENT

PRINCIPLES

The rate for laying a cable shall cover the cost of handling, placing, compacting the bedding materials up to the underside of the mainfill, in addition to any other cost associated with laying the cables.

SCHEDULED ITEMS

Take delivery of, lay and bed cables.....Unit: m

Cables will be measured as the gross length of trench excavated and approved by the Engineer plus 1,0 metre at terminal equipment and the actual measurement within a substation building.

Separate items will be scheduled for each size and type of cable specified. The rates shall cover the labour cost of taking delivery of the cable, inspecting, bedding and laying of the cables including the testing thereof

LV cable jointing.....Unit: No

Joints will be measured as complete units.

Separate items will be scheduled for each type and size of cable joints.

The rate shall cover the cost of taking delivery of the jointing material, inspecting the cable and all labour necessary for the making of each joint.

LV cable terminations.....Unit: No

Terminations will be measured as one unit per cable and not per conductor end.

Separate items will be scheduled for each type and size of cable termination. The rate shall cover the cost of taking delivery of the termination material, inspecting the cable and all labour necessary for the making of each termination.

E2.1.15 NEW LUMINAIRES

All existing luminaries in the pump stations and coagulation room shall be replaced with new LED fittings and the following fittings shall be installed as shown on the design drawings:

Type	Description/Specification	Typical Fitting
TYPE A	Surface mount 40W LED luminaire with 4000lm and dimensions of (LxWxH) 1270 x 86 x 90 mm shall consists of an injection-moulded, flame-retardant polycarbonate housing and prismatic diffuser. A powder coated white reflector and control gear tray upon which all electrical components shall be mounted and secured by means of multiple twist lock latches to secure the reflector to the housing. Silicon sponge seal shall be moulded into the housing to ensure an optimal seal between the housing and the prismatic diffuser. Two of the stainless-steel latches shall facilitate the hinging of the diffuser and ensure correct alignment when closing the diffuser. It shall be designed to operate LEDs of up to 65W.The luminaire shall come complete with constant current driver,1.7 to 2.3kg weight, mains tolerance of ± 10% at 230V voltage supply, line frequency of 50Hz, Class I electrical safety class, 10kV/10kA surge protection, power factor of ≥ 0.95, operating temperature of -30 to +35°C, enclosure tightness of IP 65 and mechanical withstand impact of IK07.	
TYPE B	Surface mount 13W LED luminaire with 2000lm and dimensions of 280mm diameter shall have base and trim ring manufactured from of high pressure die-cast marine grade, the trim ring casting shall be mounted onto the base casting by means of stainless steel M5 Allen head screws located outside the lamp compartment. The base and trim shall be finished with epoxy powder coating. An opal non-discolouring high impact acrylic injection molded diffuser shall be used and shall offer excellent vandal resistance, be highly translucent and shall not discolour even when subjected to the harshest UV environments. A silicon sponge gasket shall be fitted into a special groove in the diffuser to prevent damage to the gasket during installation and to achieve the certified ingress protection rating of IP65, It shall be designed to operate LEDs of up to 13W.The luminaire shall come complete with 300mm supply lead, constant current driver, mains tolerance of ± 10% at 230V voltage supply, line frequency of 50Hz, Class I electrical safety class, 10kV/10kA surge protection, power factor of ≥ 0.95, operating temperature of -20 to +35°C, and mechanical withstand impact of IK08.	
TYPE G	Wall mount (flood mounting) 55W 24LED luminaire with 7012lm and dimensions of (LxWxH) 3396mm x 249mm x 63mm shall have body manufactured from marine grade aluminium, high-impact polycarbonate protector and painted finish, housing shall be corrosion-resistant high-pressure die-cast and shall provide access to photometric engine and electronic assembly in case of upgrading or replacing components. The luminaire shall have certified ingress protection rating of IP66, It shall be designed to operate LEDs of up to 55W.The luminaire shall come complete with constant current driver, mains tolerance of ± 10% at 230V voltage supply, line	

	frequency of 50Hz, Class I electrical safety class, 10kV/10kA surge protection, power factor of ≥ 0.95, operating temperature of -20 to +60˚C, and mechanical withstand impact of IK10.	

E2.1.16 CONDUIT AND WIRING

Galvanised plain-end steel conduit shall be used for lighting and power installation, all conduit shall bechased into wall unless an agreement between the engineer and contractor has been reach to have it surface. All wiring shall be channelled through conduit throughout the installation and 2.5mm^2 single core stranded conductor shall be used for lighting and 4mm^2 shall be used for single phase socket-outlet points unless. Provisional quantities of conduit, wiring and small power outlets have been included in the bills of quantities. Instructions as to the final requirements will be issued during the construction stage. All items will be re-measurable.

E2.1.17 TELEMETRY

The Contractor will be responsible for the supply, installation and commissioning of a new telemetry system. The Telemetry units will be wall mounted on enclosures manufactured from 3CR12, with baked enamel finish. All Telemetry radios are to operate on the 433.05 - 434.79Mhz licence free bandwidth. All telemetry shall be 12 VDC operated with battery backup. A minimum standby time of 24 hours is required.

Coordinates for Telemetry Stations

Raw Water Pump Station

Latitude 32°25'21.70"S
Longitude 28°29'12.97"E

Blower Room

Latitude 32°25'48.39"S
Longitude 28°28'32.61"E

SCADA Room

Latitude 32°25'48.49"S
Longitude 28°28'27.08

E2.1.17.1 TELEMETRY EQUIPMENT

System Overview

The telemetry system supplied will be used for remote monitoring and control to various designated sites.

The system shall not only allow for units that accept direct I/O (e.g. digital, analogue, pulses) but also gateway units that allow direct interfacing to common industrial protocols (e.g. Modbus, Modbus Plus, Ethernet/IP, Profibus, DF1) commonly employed by various PLC vendors as well as third party equipment manufacturers.

It shall therefore be possible to have a combination of both wireless I/O and wireless gateways in a single telemetry system that can scale as the system requirements dictates. The system aims for easy setup and maintenance (by the supplier as well as end-user if necessary). The software to configure and maintain the radios shall be made freely available with this system.

It is strongly advised that radio path testing is undertaken where uncertainty lies on the reliability of the radio signal strength. The radio telemetry system shall operate in the 430 – 450MHz range with a software-adjustable RF transmit power level of up to 5W.

Principle of Operation

Radio transmissions must occur when an input signal changes (change-of-state). That is, when a digital (e.g. switch contact) input turns off or on, or when the value of an analogue input changes by a pre-configured amount (delta-change), a radio transmission should occur. There should also be regular update transmissions (configurable) to check the value of the input signals and to insure the integrity of the communications signal. The communications status shall be made available as an alarm output. In the event of a communications failure, it shall be possible to reset digital and analogue outputs to zero.

Input signals should be transmitted in a data frame which shall include the address of the transmitting module (and repeaters if used), the address of the destination module, and a CRC error check. The error check will be used to ensure that there is no corruption of the data frame during transmission. The same radio module shall have digipeating (digital repeating) capabilities as well. It shall also be possible to have peer-to-peer communications between modules – this means that wireless units can transmit directly to any other wireless unit, and can also transmit to multiple wireless units. There are no master units and no slaves and it shall be possible for all input signals to be transmitted to multiple destinations.

Each module should have handshaking capabilities over the air so that if transmitting module is suppose to receive an acknowledgment from the receiving module, and the transmitting module does not receive this acknowledgment, it should have retry capabilities. It must be possible to flag a communications failure via a digital output on the unit.

General Specifications

Power Supply:

The unit should incorporate an internal switched-mode power supply design that will accept an input voltage of 230V +-10% tolerance supply. The unit should also have a built-in battery charger to allow for an uninterrupted power supply and internally automatically switch to 12V battery backup in the event of a power failure. On return of main supply, the unit must switch back to mains operation, and charge the battery. It must also be possible to power the unit directly from a 12V battery at the battery terminals. The unit should have the ability to communicate its current state in real time to the RTU, giving the operator the ability to monitor and log voltages and currents as well as battery and AC state. The radios power circuit must have built-in intelligence and should be able to automatically alarm on loss of mains supply, loss of solar charging or low battery voltage and it should be possible to transmit these alarm signals to remote modules as digital output signals.

Inputs / Outputs Description:
See the technical specifications table below to a description of the I/O capabilities of the radio modules.

RS232 Port:

The serial port must be a 9 pin DB9 female and should provide a connection to a terminal or to a PC for configuration and testing. The port should not be used for radio data communications except in the case of wireless gateways where it could be used for interfacing to a host device such as a PLC.

RS485 Port:

All telemetry modules will have I/O expansion capability via the RS485 port in the event that outstations I/O count needs to be expanded. The units must be expandable with up to 31 remote I/O units on the RS485 bus and mounting distances of up to 1200m from the radio should be achievable. The expansion I/O should consist of several options that include Digital, Analogue and Pulse input / output variations.

Software Configuration:

The units should be easy to configure via standard Windows-based software. Programming the units can be done via a straight serial cable to the RS232 serial port. It must also be possible to extract the software

configuration from the module. The configuration software should be project-based and a single project file shall be used for the complete telemetry installation. There shall be password protection facilities for the project file to prevent unauthorized use. There software shall log and store data as required by the client for future use or reference.

Diagnostics and Testing:

The unit should provide diagnostic and test functions by connecting a PC terminal to the module. It should be possible to test both I/O and communication functions. The unit will include a radio strength measurement, which provides an indication of background noise as well as received radio strength. This feature shall allow radio paths to be tested without any additional specialized test equipment. In the case of wireless Gateways, it should be possible to read and write to the actual units data registers for testing and diagnostic purposes.

Summary of Minimal Technical Specifications for Radio Telemetry Equipment.

Remote Terminal Unit

Item	**Minimum Specification**
Communication	Data Radios, Cell SMS, Cell GPRS, RS232/485 and Ethernet etc
Features	Real-time I/O device, Intelligent Data Logger, Remote time stamping of event and logged data, Configurable and programmable from the Picasso Configuration Toolbox, modular and easily expandable, EMI Protection, Programmable with PLC Languages, Industrial standard high speed processor, On-Board 1Meg-Word Flash and Gig-Word non volatile RAM, On-Board Real-time clock and watch-dog timer , On-Board LED's indicating the Digital Input and Digital Output Status , Communication Orchestrator, Build to ISO 9000 Standards, 24 I/O's on the main processor board, DIN,8 AIN,8DOT,connects to interface modules such as I/O lightning protection units, galvanic isolation units for AIN's and 10A Interposing relay modules.
Analog Inputs (AIN)	8 Inputs, 12 Bit Resolution, 0.1 % Accuracy, Single ended, Additional AIN on expansion modules,
Digital Inputs (DIN)	8 Inputs, with LED status display, Opto-Isolated, 5 kV isolation and Additional DIN on expansion modules to accommodate all I/Os
Digital Outputs (DOT)	8 Outputs with LED status display, Open Collector, 250mA sinking per channel and additional DOT on expansion modules
Other Specifications	Voltage: 9 to 17Volts DC,120mA power consumption,2 x RS232 ports (300 to 57600 bps) RJ45(EIA-561 Compatible)
Data Reporting	Data shall be capable of being reported to any SCADA on the communication network. It shall be capable of being configured to send text messages to mobile cell phone users to report alarms

Digital Input Surge Protector

Item	Minimum Specification
Features	Digital input lightning protection, No isolation available on the module.
Supply Voltage DC	Minimum 9V, maximum 15V and standard 12V
Physical Dimension	61mm x 42mm x 80mm (LxWxH)
Connection Sockets	14-Way Ribbon to the RTU or I/O Modules, 2 x 8 way termination connectors, 4 Way Power Supply 12V+, Ground.
Protection	10kA per channel and maximum input voltage 30Vdc
Channel (I/O)	Four channels

Power Supply

Item	Minimum Specification
DC supply	13.8V (tunable), max 4.3A (split between DC output and battery charge)
AC supply	Input: 90~264VAC, 47~63Hz
Battery supply	Battery charge: max 1.5A
Battery	Low Maintenance Battery 12Volt 18Ah
Rated Power	60W
Protection	Short circuit, overload and over-voltage protection, Battery low, battery polarity protection

Data Radio

Item	Minimum Specification
Transmission Power	2W
Working Frequency	433MHz, options 402-470MHz
Power Consumption	DC5V Power, receiving current <50mA, transmitting current <1.5A/2W (<1A/1W); Sleeping current ＜1mA.
Receiver Sensitivity	-112dBm
Working Temperature	-40℃~+85℃
Output/ Input Interface	RS 232, RS 485 and TTL
Power control	One sleeping model, awaken from hardware
Circuit Structure	Radio adopts chip integration, the conversion time for transceiver should be short less than 20ms, all indications consistency and better performance
High Anti-Interference and Low BER (Bit error Rate)	Based on the GFSK modulation mode, it shall adopts the efficient communication protocol. The actual bit error rate shall be 10-5～10-6 when channel bit error rate is 10-2.

Technical Competency

The supplier of the telemetry system must have experience with the radios being supplied and should either have undergone basic training or provide an authorized letter from the local agency indicating that they are able to offer sufficient technical support on the telemetry system.

Service and Maintenance

The type of telemetry system deployed should ensure that in the event of the end user not getting satisfactory service from the supplier, they are able to seek assistance and technical support from an alternate supplier. The radio configuration software and all future revisions of it should be freely available to the end-user.

Warranty

The radio telemetry modules used must ensure long-term reliable operation. A limited lifetime warranty from the manufacturer should be included as standard on all radio telemetry modules supplied.

E2.1.19 SCADA (SUPERVISORY CONTROL AND DATA ACQUISITION) SYSTEM

SCADA system shall provide supervisory control, monitoring and management of waste water system, raw water and portable water stations by acquiring and analysing the data from these remote stations. It shall gather the real-time data from the stations, presents the data on various HMIs, records and logs the data on SCADA database management.

Radio telemetry shall gather data from other stations to the main station and the data shall be transferred from main station to the SCADA system via fibre, however the system shall be capable of gathering data from any other station during communication breakdown.

The system shall be so designed to allow addition of future stations which shall be added and form part of the entire system at later stage.

SCADA system shall store received data which shall also be used for trending, alarming, reporting and archiving, this system shall be capable of sending an alarm via sms to the relevant stakeholders in the event of unattended alarm.

The supply and installation of the system shall come complete with the software, ADSL, correctly sized computer to cater for current installation and wastewater stations which shall be added at a later stage and any other accessories which are required to supply a complete operational system.

The system shall have as a minimum, an operating system of 64-bit windows 8.1 Professional, i7 processor, 8 GB RAM and 40inch commercial type computer screen.

E2.2 ELECTRICAL GENERAL TECHNICAL SPECIFICATION

E2.2.1 SCOPE OF WORK

The Contract Works include the supply, delivery, installation, testing, commissioning handing over in proper working order of the complete services installation as described in all the constituent parts of this document.

The Contractor will be responsible to repair all other existing equipment damaged by him or his employees at his own cost. He shall therefore familiarize himself with the positions of all other equipment before he commences.

E2.2.3 ELECTRICITY SUPPLY

Electricity supply will be made available by the Supply Authority at the voltage specified in the Project Specification, and the Contractor shall then deliver the installation in such a manner that it complies with the Supply Authority's requirements regarding voltage, current and frequency and with any other requirements which may be imposed by the Supply Authority. The Contractor must arrange in good time with the Supply Authority for the electrical supply connection, this shall including among other things making application, following up, completing forms or facilitating the completion thereof as it may be required and paying of connection charges.

E2.2.4 GENERAL

E2.2.4.1 STANDARD TECHNICAL SPECIFICATION

This Standard Technical Specification specifies the standard of workmanship and quality of material for the services installation further described in the Project Specification, the Drawings and Schedules, and if applicable, in the Schedules of Quantities.

This Standard Specification must be read in conjunction with the Project Specification, which qualifies and amplifies this Standard Specification. In the event of conflict, the Project Specification shall take precedence over this Standard Specification.

E2.2.4.2 TENDER DOCUMENTS

Upon receiving a tender document, Tenderers shall ensure that all pages and drawings are included. Should any page or drawing be missing, any doubt or obscurity arise about the meaning of any section of any part of the set of documents, or should any obvious error be apparent, Tenderers shall immediately inform the Engineer for amendment or clarification. Where a Tenderer's entry in a schedule conflicts with the document prepared by the Engineer, the Tenderer shall comply with the document prepared by the Engineer and the conflicting entry shall be invalid.

The main tender shall in all aspects comply with the tender document, however, alternative offers may be made with adequate qualifications of deviations from the Engineer's document. If a main tender is not submitted, any alternative offer will be deemed invalid.

All information and prices shall be submitted with the tender. No price negotiations will be entered into after submission of a tender.

Where this tender document is written in the form of instructions, such instructions are addressed to the Contractor.

E2.2.4.3 COMPLIANCE WITH REGULATIONS AND STANDARDS

The electrical installation shall comply with the latest revisions and amendments of the following:

The South African Bureau of Standards Code of Practice for the Wiring of Premises, SANS 10142-1:2017 Part 1, referred to herein as the "Wiring Code". The Contractor has to operate strictly in accordance with the Occupational Health and Safety Act and Regulations (Act No 85 of 1993) in its entirety and it is expected of him to:

Ensure the safe operation and safety of all people on site and to strive for a proper management and clean and safe site. Register himself and Sub-Contractors in terms of the Compensation for Occupational Injuries and Diseases Act (Act No 130 of 1993) and to issue a copy thereof to the Employer.

The Employer, his employees or any of his agents do not accept any responsibility and/or liability of any kind in terms of the clauses and/of prescriptions of the Occupational Health and Safety Act for the Works or any part thereof.

If the Employer or the Engineer or their representatives stop the work because it is unsafe in their opinion, the Contractor shall not have the right to any claims in this regard.

The Contractor is fully responsible and/or liable for any act and/or action of his employees and/or equipment that operate or that are used on site. The Contractor shall liaise with the Employer if he should, for whatever reason, be unable to perform in terms of the stipulations of the said Act.

The Contractor has to appoint in writing a capable person as required by the Occupational Health and Safety Act (Act No 85 of 1993 General Safety Regulation 11.1), and a copy of such an appointment has to be delivered to the Employer. This appointed capable person has to accept the appointment in writing and it has to be clearly indicated in his letter of appointment.

The Contractor shall annually register with the Electrical Contracting Board of South Africa as required by the Occupational Health and Safety Act 85/1993.

The Municipal By-laws and Regulations and any regulations of the Supplier of Electricity.

The Local Fire Office Regulations.

Regulations of Telkom.

The relevant codes and specifications as defined under Clause 3.3.16.

The regulations of the local gas supplier where applicable.

The standard Regulations of any Government Department or other statutory body where applicable.

No claims for extras arising from failure of the Contractor to comply with any of the regulations and standards listed above will be considered.

Where conflict appears to exist between any of the regulations and standards listed above and the specification, refer such conflict to the Engineer in writing for his ruling.

Immediately after receipt of official appointment as Contractor, and at any time thereafter as may be necessary, the Contractor shall notify all relevant authorities, pay fees and take any other steps which may be required or prescribed to execute the
contract works. The Contractor shall copy related correspondence to the Engineer who shall be kept informed at all times. This shall not, however, release the Contractor of his responsibilities.

Provide, in both official languages, notices and warning signs required by statutory or regulatory requirements.

E2.2.4.4 INSPECTION, TESTS AND COMMISSIONING

On completion of erection and installation on site the Contractor shall perform all the tests that may be required by the Engineer in his presence to ensure that the Works are ready for handing over and putting into regular use.

Near completion, inspect and test the services installation in accordance with the Wiring Code, the Regulations of the Supplier of Electricity and the Occupational Health and Safety Act 85/1993. Record test results on printed test sheets and submit to the Engineer.

Testing of the electrical installation shall be in accordance with the Project Specification, but shall include but not limited to the following:

Ensure correct polarity, phase rotation and balance load between the phases. Verify polarity and phase identification.

- Continuity and resistance of earth conductor including all bonding conductors.
- Continuity of ring circuit.
- Earth electrode resistance.
- Insulating resistance.
- Earth fault loop impedance test.
- Operation of earth leakage protection devices and circuit breakers.

After inspection and testing, timeously arrange for any inspection and test by the Supplier of Electricity if required, and assist as necessary the Inspector of the Supplier of Electricity by providing access, tools, instruments and attendance.

Replace any portion of the electrical installation that does not comply with the Wiring Code or the Specification. Such replacement shall be done at the Contractor's expense.

Submit a "Certificate of Compliance by an accredited person" Annexure 1 in terms of the Occupational Health and Safety Act 85/1993, Electrical Installation Regulation 1992, to the Employer and forward a copy to the Engineer.

Carry out additional special tests as required by the Engineer and provide the required test equipment.

Timely advise the Engineer of all inspections and tests as the Engineer reserves the right to witness such inspections and tests.

Provide access, tools, instruments and attendance, to assist the Engineer who may perform verification tests at any time.

The Engineer shall have the power at any time to examine any part of the Works or materials intended for use in or on the Works either on site, or at the place of manufacture or storage.

On completion of the works, the Contractor shall submit four indexed volumes of all test certificates to the Engineer for tests done at factories and on site. (To be included in the manuals).

The Contractor shall be responsible to calculate all relay settings. The settings shall be submitted to the Engineer for approval at least 2 weeks before the commissioning of the works commences. The settings shall be substantiated by calculation sheets and graphs where applicable.

The Contractor shall check that all protection relays and overload devices are properly set to protect equipment such as motors, cables and capacitors etc., before the system is energised or any motors are switched on. Where overload devices are overrated or the ranges of relays insufficient to protect equipment, the Engineer shall be informed and the equipment shall not be energised.

E2.2.4.5 FACTORY TESTS AND INSPECTIONS

The manufacturer shall perform all routine tests in the factory as described by SANS, IEC and/or BSS as well as the manufacturers own standard routine tests on all materials, equipment and auxiliary equipment. Type tests shall be performed as described in the relevant equipment specifications.

The Contractor shall submit a list of tests and inspections to be performed on the equipment for approval.

The Contractor shall perform any additional standard tests that may be required by the Engineer.

The Engineer shall indicate which tests shall be witnessed by a representative of the Employer and the Engineer.

The Contractor shall submit four copies of the test certificates with the test results of all the tests performed to the Engineer not later than the delivery date of the equipment.

E2.2.4.6 SITE TESTS

On completion of erection and installation on site the Contractor shall perform all the tests that may be required to ensure that the Works are ready for handing over and putting into regular use.

Contractors shall provide their own test equipment which shall be of accepted standards.

The Contractor shall submit a list of tests and inspections to be performed on the equipment for approval.

The Contractor shall perform any additional standard test that may be required by the Engineer.

All the tests shall be witnessed by a representative of the Employer and the Engineer.

Four copies of site test certificates shall be submitted to the Engineer within 7 days after completion of each test.

E2.2.4.7 FIRE EXTINGUISHERS, FIRST AID, DANGER & INSTRUCTION SIGNS FOR SUBSTATION

E2.2.4.8 FIRE EXTINGUISHERS

Unless otherwise specified, 5 kg type fire extinguishers or nearest standard sizes offered by manufacturers, shall be supplied for substation building.

Fire extinguishers shall be of the CO2 type or of a type approved for the fighting of fires where electrical apparatus and oil fires are involved.

Unless otherwise specified, fire extinguishers shall be provided as follows:

- Medium voltage switch rooms: One extinguisher per 30 m² of floor area.

- Low voltage rooms - one per room.
- Transformer rooms - one per transformer.

Fire extinguishers shall be mounted on suitable wall mounted brackets.
Fire extinguishers shall be installed next to exit doors wherever possible.

E2.2.4.9 DANGER SIGNS AND NOTICES

All outside doors of all substations and all substation yard entrance gates shall be provided with a sign showing a lightning strike.

Suitable notices prohibiting unauthorized persons from entering premises shall be provided on all doors and gates of substation buildings and yards.

The following notices shall be provided and mounted against walls inside substation buildings:

- A notice prohibiting unauthorized persons from handling or interfering with electrical apparatus.
- A notice containing directions as to resuscitation of persons suffering from the effects of electrical shock.
- A notice containing directions as to procedure in case of fire.
- One set of notices called for above shall be provided and installed for each substation building
- The notices shall be displayed at a prominent position inside the building.
- The notices shall be made from suitable plastic with engraved lettering.

E2.2.4.10 MATERIALS

Materials and equipment used in this Contract shall, where possible, be of South African manufacture and shall comply with this specification and relevant SANS, BSI and IEC Specifications and shall be approved and installed to the satisfaction of the Engineer.

The Contractor shall submit samples of all materials and equipment for examination by the Engineer before installation, unless prior consent to the contrary has been obtained in writing from the Engineer. Such samples will be held for comparison with equipment and materials installed and will be released on satisfactory completion of the Contract. Similar equipment and material shall be of the same manufacture and interchangeable and be standard products from established manufacturers.

Where a certain manufacturer's material or equipment is specified, listed in the Schedules or noted on the drawings, such materials or equipment shall be provided as specified, except where an alternative is allowed.

Where certain products of a specified manufacturer are unobtainable, substitutes may be offered, but shall only be supplied after written consent by the Engineer.

Where the words 'or approved alternative' follow a manufacturer's name and catalogue reference, the materials shall be of the specified manufacture and reference, or, if the Contractor wishes to use a substitute the onus shall be on the Contractor to prove such substitute is equivalent to the specified manufacture and reference. The decision, as to the acceptance of such substitute, shall rest solely with the Engineer, whose decision shall be final. If the Engineer instructs the Contractor to install the materials of the specified manufacture and reference, then no alteration to the Contract Sum or rates shall be permissible.

The Engineer may instruct the Contractor to supply material or equipment and/or install any other make or manufacture of equipment than that specified and will issue variation orders where such change has cost implications.

Where a detailed specification for material or equipment is not provided, the Contractor shall select such material or equipment to comply with normal practice and to suit the particular application in all respects.

E2.2.4.11 FINISHING AND PAINTING OF MATERIALS AND EQUIPMENT

The Contractor shall select materials and their finishing to avoid corrosion.

Exterior applications within 50 km of the coast shall be deemed corrosive.

Aluminium shall be anodised to SANS 999 - 1986 Grade A for exterior and Grade B for interior applications.

Unless otherwise specified, finish steel as follows: -

Interior Applications, And Non-Corrosive Exterior Applications

Galvanize to SANS 763 - 1988, or paint by :

- Preparing surface to SANS 064;
- Priming with zinc chromate to SANS 679 Type I of dry film thickness of 25 microns (minimum); and
- Applying two final coats of high gloss enamel paint to SANS 630 Grade 1, each coat of dry film thickness of 25 microns (minimum).

Exterior Corrosive Applications

- Hot dip galvanize to SANS 763 - 1988;
- Prepare surface to SANS 064 and prime with calcium plumbate to SANS 912 of dry film thickness of 25 microns (minimum);
- Apply undercoat to SANS 681 Type 2; and
- Apply two final coats of high gloss enamel paint to SANS 630 Grade 1, each coat of dry film thickness of 25 microns (minimum).

NOTE: Measure dry film thickness to SANS Standard Test Method 140 or 141.

Hot dip galvanise steel after all fabrication. Reinstate damaged hot dip galvanising (SANS 763) with hot zinc spraying. Reinstate damaged electro galvanizing with two coats of zinc-rich paint.

Any unpainted steel shall be chromium-plated or similarly plated to approval.

Where required paint aluminium surfaces as follows: -

- Thoroughly clean.
- Apply a self-etch primer to SANS 723 Plascon Hi-Sheen or approved alternative.
- Apply two final coats of high gloss enamel paint to SANS 630 Grade 1, each coat of dry film thickness of 25 microns (minimum).

E2.2.4.12 FIXING OF MATERIALS

Fix luminaries, metal draw boxes on surface, industrial surface mounted switches and plugs, metal channels, wiring troughs or trays, cable trays, saddles, conduit accessories, brackets, braces, trunking and all other surface-mounted material and equipment only as described below :

- Concrete (in situ) - expanding cast-in, or gun-bolted, metal screw-fasteners.
- Precast concrete - only with permission of the Engineer.
- Brickwork - expanding, or built-in metal screw fasteners.

- Ash brick - "J bolts" or approved alternative.
- Steelwork - drilled, gun-bolted, or tapped and screwed metal screw fasteners; or steel gun-bolt nails or, where permitted by the Engineer, welding.
- Woodwork - woodscrews, not nails.
- Hollow tiles - spring toggles of not less than 6 mm diameter, but only with permission from the Engineer.

- Exposed to weather - solid brass or stainless-steel screw-fasteners.

Where any equipment or material is to be mounted on the surface of ceilings, false ceilings, dry wall partitions, gasbeton or other specialised surfaces, mount such equipment or material only as specified by the Engineer or as permitted by the Engineer in writing.

Where sizes of fasteners etc. are not specified, submit samples and proposals to the Engineer for approval.

Do not gun-bolt into ash bricks, brickwork, gas-beton or precast concrete, except as permitted by the Engineer in writing.

The Contractor will be held responsible for any damage to Builder's work due to unauthorised inadmissible gun-bolting.

Do not use plastic plugs, wooden plugs or any other soft substance type plugs.

"Fischer", or approved alternative hard nylon plugs of not less than 6 mm diameter may be used for fixing light materials to suitable surfaces.

Plugs shall not be installed in mortar joints between bricks.

Provide suitable washers under screw heads and nuts.

Install materials in accordance with manufacturer's instructions and recommendations in all respects including type, size and spacing of fixings.

E2.2.4.13 INSTALLATION

(a) The Contractor shall check the dimensions of access ways and the space provided for DBs, MCCs and other panels on the latest architectural drawings to ensure that the enclosures are appropriately designed.

(b) Unless otherwise stated in the Project Specification, floor-mounted enclosures shall be mounted over cable trenches. Trench bridging supports shall be provided at the ends of the enclosure and at every second section. The supports shall be manufactured in the form of a top-hat section from 3 mm thick steel and then hot-dip galvanised.

E2.2.4.14 LOW VOLTAGE SWITCHGEAR AND CONTROLGEAR

General

Switchgear, control gear and instrumentation shall be rated for the system voltage, frequency and number of phases and for the load current and applicable maximum prospective fault current as specified on the drawings and the Project Specification.

Surge arresters

Surge arresters shall be provided for each phase in all boards, connected to each phase of the incoming cables.

Surge arresters shall conform to the relevant SANS codes and other Specifications, shall bear the SANS mark, and shall be solidly earthed directly onto the cubicle earth bar by means of a copper strap and be as short and straight as possible.

Air circuit breakers (ACBs)

ACBs shall be of the metal-clad, with-drawable type complying with the relevant codes and specifications. Unless otherwise stated in the Project Specification, the ACBs shall be three pole.

ACBs shall have an adjustable thermal overload trip unit and an adjustable magnetic short-circuit trip unit. All trip units shall be direct acting. Both trip units shall be replaceable by units of different ratings.

The ACBs noted on the drawings as "selective" shall incorporate an adjustable time-delay on the magnetic short-circuit trip unit.

ACBs shall be designed for trip-free manual closing and electrical tripping of the type specified in the project specification or drawings, e.g., shunt, remote or under voltage tripping; delayed contacts; AC or DC coil voltage.

Interlocking shall be provided to ensure that an ACB is fully isolated before access to any live terminals can be obtained.

ACBs shall be horizontally withdrawable allowing full maintenance and tests without the breaker having to be removed from the withdrawal mechanism.

Interlocks shall be provided to allow an ACB to be operated in the withdrawn maintenance/test position, and to prevent the circuit breaker from being closed unless fully in the engaged or test position and from being moved when the mechanism is closed.

Special equipment should not be required to remove the circuit breaker from its withdrawal mechanism for transporting. If special equipment is required, it shall be provided with the circuit breaker.

Lockable safety shutters shall be provided to screen the fixed contacts and shall operate automatically with the movement of the circuit breaker.

All non-current-carrying metal parts of the circuit breaker shall be solidly interconnected and connected to an earth contact which shall engage with a
copper plate connected to the main earth bar of the cubicle, and the arrangement shall be such that the circuit breaker frame is earthed before the circuit breaker contacts engage with the live fixed contacts.

A mechanically operated "ON/OFF" or ("I/O") position indicator shall be incorporated.

Facilities for padlocking in the "off" position shall be provided.

Two normally open and two normally closed spare auxiliary contacts shall be provided, unless otherwise noted. It shall also be possible to install a change-over contact if required at a later stage. Auxiliary contacts shall be capable of making and carrying continuously 1A AC or DC. They shall be capable of breaking 500 VA AC at 0,2 PF and 20 watts DC at an L/R of < 40 ms.

Where noted on the drawings special purpose interlocking (key/mechanical/electrical) shall be provided between ACBs.

Unless otherwise stated in the Project Specification, the ACBs shall have a one second fault withstand rating.

MOULDED CASE CIRCUIT BREAKERS (MCCB's**)**

Moulded case circuit breakers shall comply with the relevant codes and specifications. MCCB's shall be of flush panel mounting type.

MCCB's with ratings of 100 A and less shall be suitable for mounting on a DIN rail.

MCCB's with ratings in excess of 100 A for distribution networks shall each have an adjustable thermal overload trip unit and an adjustable magnetic short-circuit trip unit. Both trip units shall be replaceable by units of different ratings. MCCB's for motor starter circuits shall be of the current limiting type with an adjustable magnetic short circuit trip unit.

MCCB's with ratings of 600 A or more shall have extension type operating handles, which shall be interlocked with the enclosure compartment doors to prevent the door being opened unless the MCCB is in the off position.

Mechanically coupled single-pole circuit breakers used as double or triple-pole circuit breakers are not acceptable unless overload releases are internally coupled.

The fault current interrupting rating of MCCB's shall not be less than the maximum prospective fault current and not less than 5 kA.

Neutral bars associated with each bank of MCCB's shall be positioned below each bank and shall be wired in the same sequence as the MCCB's.

MCCB's with shunt release shall have an auxiliary contact arranged to interrupt the shunt release current at the end of the opening operation. MCCB's with an under-voltage release shall be equipped with a time delay relay when specified.

MCCB's shall be fitted with the specified number of spare auxiliary contacts.Where spare auxiliary contacts are not called for, it shall nevertheless be possible to fit at least one normally open and one normally closed contact or a change-over contact at a later stage. Auxiliary contacts shall be capable of making and carrying continuously 1A ac or dc. They shall be capable of breaking 500VA ac at 0,2 PF and 20 watts dc at an L/R of < 40ms.

Where called for, MCCB's shall be capable of remote closing using the specified control voltage.

MCCBs shall be lockable in the "off" position. A separate locking device may be used for this facility if so stated in the Project Specification.

Current limiting MCCB's will not be allowed unless otherwise stated in the Project Specification. 4.13. Where MCCB's are of the current limiting type the Contractor shall determine, and offer suitable ratings in collaboration with the MCCB supplier, to ensure discrimination and adequate short-circuit current capability. Calculations shall be submitted with the tender indicating the degree of current limiting and discrimination achieved as well as techniques used. Full details shall be submitted of the current limiting characteristics of each MCCB rating offered.

MCCB's for DC application shall be of the current limiting type and shall have at least one pole in the positive and one pole in the negative circuit. Where additional poles are required in series to meet requirements of the specified application, the series connections between poles of like polarity shall be such that they cannot be removed without special tools.

DISCONNECTORS

All disconnectors shall be of the "load-break-fault-make" type i.e. be switch disconnectors complying with the relevant SANS specification.

The disconnectors shall have the ratings specified on the drawings.

The handle of the disconnector shall form part of the panel door. It shall not be possible to close the disconnector without the door being closed and it shall not be possible to open the door without the disconnector being switched off.

Disconnector handles shall have an integral key lock or padlocking facility.

The fault carrying capability of the disconnectors shall be equivalent to or higher than the fault level of the associated busbar but not less than 5 kA.

SWITCHES AND SELECTOR SWITCHES

Switches and selector switches shall be switch disconnectors complying with the relevant SANS specification.

Switches and selector switches shall be capable of carrying, making and breaking the full rated current and of making onto the maximum prospective fault current.

The fault rating of switches and selector switches shall not be less than the maximum prospective fault current and not less than 5 kA.

The operating knob and indicator plate shall be manufactured of insulating material and the switch positions shall be clearly and indelibly marked thereon.

The switches and selector switches shall be provided with substantial contacts and the terminals shall be clearly marked and arranged for easy wiring.

The voltmeter or ammeter selector switch shall be mounted directly below the associated volt or ammeter.

Voltmeter selector switches shall be arranged so that voltages between phases, and phases to neutral, can be read. Voltmeter selector switches shall be of the break-before-make type.

The voltmeter selector switch shall have one "off" and six "metering" positions and shall be suitable for panel mounting in such a way that the operation knob and indicator plate can be mounted on the front of a panel and the switch itself at the back of the panel.

Ammeter selector switches shall be of the make-before-break type with one "off" and four "metering" positions arranged to read the current in each phase and in the neutral. When in the "off" position the metering circuit shall be short-circuited.

The physical construction of ammeter selector switches shall conform to that of voltmeter selector switches.

Switch enclosures shall be provided with an interlocked cover to ensure that the switch is in the "OFF" position before the cover can be opened for inspection or fuse removal. It shall not be possible to close the switch without the cover being closed.

Switches shall be provided with a clear "ON/OFF" or "I/O" position indicator.

TIME SWITCHES

The contacts shall be silver-to-silver or other approved single-pole changeover contacts rated at 16A and operated by a spring-driven clockwork, electrically wound with a spring reserve of 8 hours minimum.

Time switches shall be fitted with a manual overriding switch.

An external bypass switch shall be provided in each time switch circuit.

Time switches shall have the following features :

- daily programmable with minimum 30 minute "on" and "off" control facilities.
- weekly programmable with day omission facilities of minimum 12 hours, i.e. mornings or afternoons;

The whole mechanism shall be totally enclosed in a dust-proof enclosure.

PHOTO SWITCHES

Photo switches shall comply with the relevant codes and specifications.

Photo switches shall have silver to silver or other approved single-pole changeover contacts rated to switch a reactive load of 1800 VA at 230 V and 50 Hz.

An external bypass switch shall be provided in each photo switch circuit.

The photo-electric cell shall switch streetlights "ON" when daylight drops to approximately 40 lux and it shall switch "OFF" at approximately 80 lux.

The photo-electric cells shall have a time delay of not less than 30 seconds.

Photo-electric cells shall be completely waterproof and shall be of robust construction.

The material of the cover shall not crack, deform or deteriorate in any way whatsoever and shall be colour-fast in all weather conditions.

The photo-electric cells shall be provided with built-in lightning arresters.

Samples of photo-electric cells shall be submitted to the Engineer for approval prior to the ordering thereof.

The prices for the erection of photo-electric cells shall include the supply and delivery and the connection of cables, etc., from the photocells to LV cubicles, DB's or mini-subs.

COMBINATION FUSE-SWITCH (CFS) UNITS

The fuse-switch units shall comply with the relevant codes and specifications and shall be fitted with high rupturing capacity (HRC) cartridge type fuses-links complying with the relevant codes and specifications.

Fuse-switches shall be capable of breaking the full rated current and shall have a fault current rating of not less than the maximum prospective fault current and not less than 10 kA for one second.

Fused isolators, i.e. fuse-switches which rely on the fuses to reduce the fault current through the switch portion to provide a higher fault current rating, are not permitted.

Fuse-gear with the fuses mounted in the cover of the unit, with one cover forming the operating lever, are not permitted.

Fuse-switch units shall have chassis and be designed to accommodate HRC fuse links. Fuse-switch units shall be of the double air-break, quick-make, quick-break type and shall have a spring mechanism smoothly driven by springs on both sides of the mechanism.

The fixed contacts shall be shrouded and arranged so that when the switch is in the open position the double-break isolates the HRC fuse links so that they can be replaced in complete safety.

Fuse-switch units shall be triple-pole units and neutral links shall be provided inside the back of the distribution boards to facilitate routine testing.

All components shall be capable of continuously carrying rated current without excessive temperature rise.

Fuse-switch units shall be provided with interlocks such that:

- The cover panel cannot be opened whilst the switch is closed; and
- the unit cannot be operated with the cover open unless an interlock is purposely defeated.

The fuse-switch shall have a handle and an ON/OFF position indicator mechanically operated by the moving contacts to ensure accurate and positive indication.

Provide facilities for padlocking in the "off" position.

In all cases, the top terminal of fuses shall be the live terminal.

Six spare fuses shall be provided for each rating fitted.

FUSE LINKS AND HOLDERS

Fuse links shall be high-rupturing capacity (HRC) cartridge type fuse links conforming to the relevant codes and specifications.

HRC fuse link holders shall be of the with-drawable bakelite type and shall conform to the relevant codes and specifications.

Each fuse link and holder shall incorporate a visual inspection eye for fault location.

Fuses protecting a specific instrument shall be mounted as a group in close proximity to the relevant instrument.

A label with the rating of each fuse shall be mounted in close proximity to the relevant fuse holder or fuse switch.

Striker pin switches shall be provided if specified in the project specification in order to trip the associated breaker or contactor to prevent the occurrence of single phasing.

Six spare fuses shall be provided for each rating fitted.

The spare fuses shall not be used by the Contractor during erection, commissioning or maintenance.

EARTH LEAKAGE PROTECTION UNITS

Earth leakage protection units shall conform to the relevant codes and specifications.

All single and three phase socket outlets shall be provided with earth leakage protection devices unless specifically excluded in the Code of Practice for the Wiring of Premises.

All units shall have test push buttons and, unless otherwise specified the sensitivity shall be 30 mA.

Earth leakage shall be arranged to disconnect the faulty circuit from both phase and neutral of a single phase system, and from all three phases of a three phase system.

CONTACTORS

All contactors for low voltage shall be of the electro-magnetic operated air-break type with specific requirements as specified in the project specification or drawings e.g. AC or DC coil voltage; dip-proofing, latched contacts etc.

Contactors shall be in accordance with the relevant codes and specifications. Category AC3 or DC2 shall in general be used, whichever is applicable. Category AC4 and DC3, whichever is applicable, shall be used for heavy plugging and inching duty systems, e.g. cranes, etc.

Contactors shall have suitable capacities for direct-on-line starting, star delta starting or any other form of starting, whichever is specified in the project specification and the drawings. The contactors shall be rated for at least 130% of the associated load current.

Each contactor shall be provided with at least two normally open and two normally closed auxiliary contacts, unless otherwise specified.

Contactors shall be suitable for remote and automatic operation where specified. Where the number of auxiliary contacts required for remote and automatic operation is greater than can be accommodated on the contactor, an auxiliary relay or on additional contactor, shall be provided.

Each contactor shall be capable of carrying, making and breaking overcurrent's during the operating time of its own overcurrent tripping devices at a recovery voltage of 90% of the specified system voltage.
All Contactors for starting squirrel-cage motors direct-on-line shall be rated to break 10 times the full-load running current of the motor.

The contactor shall be co-ordinated with the short circuit protective device to ensure adequate protection for the specified operational current, voltage and the corresponding utilisation category according to Type 2 Co-ordination as per IEC 947, i.e. that, under short-circuit conditions, the contactor or starter shall cause no danger to persons or installation and shall be suitable for further use.

E2.2.4.15 EARTH BARS

A main earth bar shall be mounted at the bottom along the full length inside the switchboard and may be bolted to the framework of the switchboard. For back access switchboards, the earth bar shall be mounted at the rear. The steelwork of a switchboard and in particular gland plates shall be solidly and effectively bonded to the main earth bar. Earth bars shall have sufficient ways for all the earth conductors and, in addition, 30% spare space shall be provided.

Switchboards with short-circuit ratings in excess of 5 kA shall be equipped with a copper earth bar with a cross section not less than S = 0,006 x I mm² where "S" is the area in mm² and "I" is the maximum prospective fault current in Amps. However, in main DBs and MCCs, the earth bar shall not be less than 70 mm x 8 mm in cross-section, and shall be fitted with earthing studs in each section of the enclosure.

Switchboards with short-circuit ratings not exceeding 5 kA shall be equipped with an earth bar comprising box terminals with pressure shoes on a rectangular copper bar measuring at least 2,5 mm x 12,5 mm mounted on insulating pedestals. An earthing stud shall be welded to the metal tray of the distribution board. An earthing conductor equal in cross-sectioned area to the incoming earthing conductor shall connect this earthing stud to the earth bar.

E2.2.4.16 CURRENT TRANSFORMERS

Current transformers shall comply with the relevant codes and specifications and shall be marked clearly and indelibly as specified therein on a rating plate securely attached to the transformer.

Each panel shall be equipped with the current transformers as specified in the Project Specification and or drawings.

Current transformers shall be suitable for a system with an effectively earthed neutral or an non-effectively earthed neutral as specified in the Project Specification.

For current transformers with a system voltage less than 3,6 kV the insulation level shall be determined by the rated short duration power frequency withstand voltage e.g. 2 kV for a 400V system.

Current transformers with system voltages greater than 3,6 kV shall be insulated to withstand test voltages defined by the rated lightning-impulse and short-duration-power-frequency voltages and shall be as follows for indoor switchgear:

HIGHEST VOLTAGE FOR EQUIPMENT R.M.S. **KV**	**RATED LIGHTING-IMPULSE WITHSTAND VOLTAGE (PEAK) KV**	**RATED POWER-FREQUENCY SHORT DURATION WITHSTAND VOLTAGE (r.m.s.) KV**
3.6	40	10
7.2	60	20
12	95	28
24	125	50
36	170	70

The short-time thermal and dynamic current rating of current transformers shall not be less than that of the associated circuit breaker, isolator or busbar.

The rated primary currents of current transformers shall be 10, 15, 20, 30, 50 and 75 Amperes or their decimal multiples.

The current transformers secondary ratings shall be 5A unless otherwise specified.

Current transformers shall be accessible and easily removable. All current transformers of any one type and rating shall be identical and interchangeable with one another.

The class of insulation of current transformers shall be Type A (maximum temperature rise 60°k) unless otherwise specified.

Protection current transformers shall be of the low reactance type having toroidal cores with fully distributed secondary windings. Turns compensation shall not be utilized on protection current transformers.

The error in turns ratio on any tapping of a Class X current transformer shall not exceed ±0,25%.

The same set of current transformers shall not be used for both indication instruments and protective relays, separate cores having a low saturation factor (<than 5 preferably) shall be used for metering.

The VA ratings shall be sufficient to operate the various metering equipment and relays but shall not be less than 10 VA.

The accuracy limit factor of the protection current transformers shall be 15 unless otherwise specified.

The following classes of current transformers shall be used.

FUNCTION	DESCRIPTION	CLASS
Metering	kVA, kW and KWh meters	0,5
Indication	Indication Ammeters	1,0
Protection	Protection Over-current, earth fault and thermal overload	10P

The arrangement of the current transformer cores with respect to the primary terminals and mechanism of the circuit breaker shall be approved by the Engineer prior to manufacture.

Where it is not possible to easily read the rating plates of current transformers, additional rating plates shall be located on the rear inner panel of the breaker cubicle relay compartment for each current transformer where they can be easily read. These shall be a duplicate of the rating plates which appear on each current transformer. In addition, the phase colour with which each current transformer is associated shall appear beneath each rating plate. Information shall be provided on the above rating plates to indicate which secondary terminals are associated with which winding. This information shall be in addition to that called for in the relevant codes and specifications. The information on the additional plates shall include the relative arrangement of the current transformer cores with respect to the circuit breaker terminals and shall also indicate their polarity.

Secondary windings of current transformers shall be earthed to the approval of the Engineer at one point only. Each group of current transformers (i.e. protection, metering, etc.) shall be earthed directly to the earth bar by way of isolating links of the type where the link cannot be removed from the terminal. These links shall be readily accessible and safe with the circuit breaker in the isolated position. They shall not be in a live compartment.

All current transformer connections shall be brought to a terminal block in an easily accessible position inside the switchgear relay panel. If remote metering is specified in the project specification, then the metering current transformer shall also be wired to an easily accessible terminal block at the back of each panel. A metering test block with special links shall be provided to make changes to the remote metering circuits possible without the danger of opening the CT's on load.

Each LV current transformer shall be of the ring type and be provided with a robust mounting bracket and approved terminal studs on the circumference of the coil for the connections. The current transformers shall be mounted on rigid supports in such a manner that the axis of the coil is in a vertical plane to facilitate the threading through of the interconnecting wiring to the relevant switchgear.

Current Transformer Testing

Test certificates shall be submitted to the Engineer and be included in manuals. Test shall be executed in accordance with the relevant codes and specifications.

Type Tests

Type tests are not required if the manufacturer holds certificates of type tests on a similar transformer. Type test certificates shall be provided upon request by the Engineer.

Routine Tests : General

Verification of terminal markings and polarity tests.

Insulation test shall be made on the windings as specified as follows:

- Power frequency tests on primary windings and measurements of partial discharges.
- Power frequency tests on secondary windings and between sections of primary and secondary windings.
- Overvoltage interturn tests.

Additional Routine Tests for Measuring Current Transformers

- Tests shall be performed to verify limits of current error and phase displacement.

Additional Routine Tests for Protection Current Transformers: Class 10P

- Tests shall be performed to verify limits of current error and phase displacement.

- Tests shall be performed to verify limits of composite error.

- Secondary winding resistance corrected to 75°C.

Additional Routine Tests for Special Purpose Current Transformers: Class X

- Routine tests shall be performed to verity and establish the following:

    - Rated knee-point e.m.f.
    - Exciting current.
    - Secondary winding resistance corrected to 75°C.
    - Turn ratios.
    - A magnetising curve shall also be provided to the Engineer for Class X current transformers prior to the installation of current transformers in the switchgear.

E2.2.4.17 WIRING IN DB's, MCC's AND PANELS

In general all internal wiring in the cubicles shall be carried out in 600V PVC insulated copper multi-strand conductors. If the internal ambient temperature of the cubicle is likely to exceed 50°C silicon rubber insulated stranded copper conductors shall be used. The minimum cross-sectional area for control circuits shall be 1 square mm and 2.5 square mm for load and CT circuits. The current carrying capacity of conductors shall be determined in accordance with the relevant codes and specifications taking the appropriate correction factors for ambient air temperatures, grouping and condition of use into account.

Where several conductors are used, these shall be neatly grouped and bound together in groups not exceeding 10 conductors and shall be arranged in neat vertical or horizontal rows or installed in PVC trunking with slotted sides. Wiring shall follow the board construction features as far as possible without the twisting or crossing of conductors.

No joints will be allowed in internal wiring, and all connections to busbars or earth bars shall be made with approved tinned copper cable lugs soldered or crimped to the ends of the conductors and bolted to busbars by means of cadmium-plated high tensile steel bolts and nuts provided with spring washers. Connections of conductors to equipment i.e. circuit breakers, isolators or contactors shall be made by a ferrule of correct size or by the soldering of the end of the conductor. Conductors connected to terminal blocks need not to be soldered or ferruled. Conductors terminating on meters, fuse holders and other equipment with screwed terminals shall be fitted with pre-insulated lugs. The lugs shall be soldered or crimped to the end of the conductor. The correct amount of insulation shall be stripped from the end to fit into the terminal. Strands may not be cut from the end of the conductor. Crimping tools used shall be of the ratchet type and indent an identifying symbol on the terminal insulation.

All wiring is to be kept free and away from any exposed terminals or other uninsulated current carrying parts. Wiring shall also be kept free from metal edges and shall be protected where they cross metal edges. Grommets shall be installed in each hole in the metalwork through which conductors pass. Connections to equipment on swing doors shall be arranged so as to give a twisting motion and not a bending motion to the conductors.

Only wires of the same potential shall be grouped together and power control circuit wiring shall be in separate wiring channels. Wiring channels shall not be more than 60% full.

Wires shall be clearly marked at all termination points in accordance with the numbering of the board manufacturer's wiring diagram, by means of suitable markers.

Additional red cable markers marked "T" in white shall also be fitted on wires associated with trip circuits.

When the board main disconnector or local disconnector is switched off, no live incoming or other wiring shall be accessible. The incoming terminals shall be screened or inaccessible. Where connections are taken from the incoming sides of the main switch, they shall be screened by a screen marked "ISOLATE FEEDER BEFORE REMOVING SCREEN". If any circuits are energised from other sources, clear warning notices to that effect shall be fitted and such terminals shall be clearly marked.

All control terminals shall be accessible from the rear, except in the case of front access boards.

Where neutral connections are looped between the terminals of instruments a common lug or ferrule shall be used to ensure that the neutral is not broken when the instruments are removed.

The supply end connections to all equipment shall always be at the top and the load end connections at the bottom.

Solid copper busbars shall be used to connect equipment to the main busbars where the current rating exceeds 200A and shall be insulated by means of at least two half lapped layers of PVC tape.

A maximum of two conductors shall be used per equipment terminal.

Where small leads are connected directly onto busbars, such as for voltmeters, etc. they shall be provided with a 20A fuse mounted directly on the busbar and a 2 Amp fuse at the piece of equipment on the front of the panel.

Unless otherwise approved the following insulation colours shall identify wiring:

Description	**Colour**
Red phase of 3-phase circuits	red
White phase of 3-phase circuits	white
Blue phase of 3-phase circuits	blue
Live of single-phase circuits	red
Neutral	black
Earth	green/yellow
Alarm circuits	orange
AC control circuits	red
DC control circuits	blue
Neutral	black
Instruments	grey

In DBs and MCCs, accessible PVC wireways shall be provided for wiring between compartments. Signal cabling shall be run in galvanized steel conduit.

Internal wiring shall be kept separated from external wiring and, as far as possible, the internal serving of cables entering the enclosure shall be left around conductors until the cable enters the compartment to which it is connected.

Low current signal cables shall be kept separate from power cables up to the point where the conductors are connected to the terminals on the equipment. Where required, Sheetmetal wireways shall be provided to ensure this separation.

E2.2.4.18 GLANDS AND GLAND PLATES FOR PVC AND PILOT CABLES

Glands

Mechanical cable glands and flameproof glands shall comply with the relevant codes and specifications.

When specified in the project specification glands shall be weatherproof, dust ignition proof, hose-proof or for use on type 'e' enclosures i.e. use in explosive gas atmospheres.

Glands shall be provided with brass locknuts and double outer sealing in corrosive environments. Areas which are classified as highly corrosive shall be equipped with H-C (Hydrocarbon resistant) or UV-C (Ultra-Violet and chemical resistant) seals as may be applicable.

Glands and components shall be manufactured of non-corrosive material such as nickel plated brass.

Adjustable cable glands of the correct size designation shall be provided in switchboards for all cable types as specified.

Glands shall be equipped with cable or armour gripping devices as may be applicable and shall be constructed to ensure electrical earthing continuity between the armour of the cable and the gland plate or the metallic structure. Glands shall be provided with an earthing bond attachment of acceptable rating.

It shall be possible to convert glands for armoured cables to be suitable for unarmoured cables by replacing the cone bush and compression ring with a rubber compression bush and rings.

Where cables with metal screens or metal sheaths are specified the gland shall be designed to earth the screen or sheath through the gland on the earth bar. It shall be possible to bring earth continuity conductors through glands for ECC cables without having to cut grooves in the barrel or cone bush. Suitable replacement parts shall be used.

Glands for outdoor use shall be equipped with a waterproofing shroud and an inner seal kit.

All pilot cable ends shall be made off in glands as prescribed by the manufacturer, of correct size and complete with neoprene shrouds if used outdoors at mini-subs or outdoor cubicles. The armouring shall be clamped between substantial tapered sections, which form an integral part of the gland, secured by lock nuts to give a earth connection.

Gland Plates

Gland plates for cable entries to boards will be from above and/or from below as specified in the drawings of project specifications.

Gland plates shall be at least 200 mm above the normal floor level.

Gland plates shall be from non-magnetizing material where single core cables are terminated to the boards.

E2.2.4.19 SWITCHBOARD ACCESSORIES

Control Push Buttons

General

Push buttons shall comply with the relevant codes and specifications.

Push buttons shall be provided by a single reputable supply and shall be selected for the required rating, contact action, duty, environmental conditions e.g. temperatures and vibrations and mounting characteristics e.g. flush mounted, enclosed, self-contained, illuminated, etc.

All push buttons shall be of the same physical dimension and shall be interchangeable between normally open and normally closed contacts. Push buttons shall preferably also be interchangeable with indicator lamps, key switches, etc. All push buttons shall be provided with replaceable lenses.

Push button terminals shall be suitable for conductor sizes to be used. Push button assemblies mounted on doors of control boards shall be enclosed to prevent inadvertent contact with the terminals and when the doors are open.

Contacts shall be silver-tipped or be constructed of an approved high quality material.

Push buttons shall be labelled by means of removable legend plates clearly indicating it's function. Legend plates shall be interchangeable.

When specified keylock push buttons shall be supplied with duplicate keys. The removal action of the key shall suit the application.

Illuminated push buttons shall comply with the specification for indicator lamps and lights.

Motor Control Centres

All motor control cubicles shall be provided with "STOP/START" push buttons as follows (or as specified in the Project Specification):

Description	**Colour**
Start Button	Green
Stop Button	Red

When specified in the Project Specification or indicated on drawings the following push buttons shall be provided:

Description	**Colour**
Trip Reset Button	Black
Emergency Stop Button	Red with yellow background
Lamp Test Button	White
Any Other Function Button	Pale Blue

Start push buttons shall have normally open contacts. Stop push buttons shall have normally closed or normally open contacts, as may be required.

Switchgear

When specified in the Project Specification or indicated on drawings push buttons shall be provided as follows:

Electricity Controlled Switchgear

Description	**Colours**
Open Button	Green (O)
Close Button	Red (I)
Reset Button	Black
Lamp Test Button	Yellow
Any other Function Button	Pale Blue

Signal Lights

General

Indicator lights shall comply with the relevant codes and specifications.

Indicator lights shall be provided as specified in the Project Specification and indicated on drawings.

Similar cluster multi-led (8 chip) long life signal lamps shall be provided for all indications.

LED's shall be selected and rated for the specified control voltage and shall be equipped with a suitable current limiting protection resistor. Each LED shall be provided with a Zener transient protection diode. Suitable LED's are type MDA 22 for AC applications under 110V and DC applications, and type MAC 22 for AC applications above and including 110V as obtainable from Mimic Crafts. Equivalents shall be submitted for pproval by the Engineer.

Indicator light lenses shall be of the same size, shall have a minimum diameter of 22 mm and shall be of the front removable screw type. The lamps shall be replaceable from the front of the panel without the use of tools. Indicator light construction shall be suitable for the operating environment and shall be equipped with interchangeable lenses.

Indicator lights shall be labelled by means of a removable legend plate clearly indicating it's function. Legend plates shall be interchangeable.

Two spare lamps shall be provided for each type and colour lamp used on the boards unless otherwise specified.

The spare lamps shall not be used by the Contractor during erection, commissioning or maintenance.

Motor Control Centres

When specified in the Project Specification or indicated on the drawings, the following indicator lights shall be provided:

Description	**Colours**
Drive stopped, power available	White
Drive running	Green
Drive tripped	Red
Emergency stop activated	Yellow
Moisture ingress	Blue

Switchgear

The following lens colours shall be used:

Description	**Colours**
Circuit Breaker, Isolator closed or abnormal state	Red
Circuit Breaker tripped (caution)	Yellow
Circuit Breaker open (ready for operation)	Green
Interlocking	White
Other functions	White

Note: Painted lenses shall not be acceptable.

Where indicating lamps are supplied from the substation batteries, it shall be separately wired to an easily accessible terminal block at the back of the board and shall not form part of the wiring of the spring charge mechanisms of equipment or tripping circuits. The indicator lights shall be wired to a lamp test push button

mounted on one of the cubicles, preferably a bus-coupler or an incomer. The lamp test circuit shall be equipped with a timer (0-10 min) to prevent the unnecessary drainage of batteries.

E2.2.4.20 NAME PLATES AND LABELS

NAME PLATES

All equipment shall be provided with a manufacturer's name plate/plates fixed in an easily accessible and readable position on equipment or inside cubicles showing the following data.

The manufacturers name or trademark.

Type, designation or identification number or other means of identification making *it possible to obtain relevant information from the manufacturer of equipment.

SANS or IEC Designation.

Rated operational voltage.

Short circuit strength in kA.

Degree of protection IP rating.

Maximum current carrying capacity of busbars.

Maximum current carrying capacity of equipment.

Voltage transformer ratio (where applicable).

Current transformer ratio, burden, class and knee point voltage (where applicable).

Current transformer connection instructions for various CT ratios (where applicable provide separate nameplate close to the relevant terminal blocks).

LABELLING

Labels shall generally have black lettering on a white background. Danger and safety notices shall have red lettering on a white back- ground and be in both official languages.

Labels shall be engraved "trafolite", aluminium or an approved alternative secured with screws, not glue, or in an approved aluminium guide rail.

Lettering shall generally be 6 mm high except that of "main switch", "hoofskakelaar", "local switch" and "plaaslike skakelaar" which shall be 10 mm high. The lettering of labels indicating names of panels shall be 20 mm high.

Each cubicle shall also be provided with labels of similar wording at the back of the cubicle.

Where possible labels shall not be fixed to removable panels or doors.

The manufacturer shall consider the wording on the drawings as preliminary only and shall obtain the correct final wording from the Engineer before the labels are manufactured.

All equipment situated inside the board, e.g. contactors, relays, fuses, timers and time switches, shall be clearly labelled indicating function and circuit controlled.

Typical labels are as follows: -

Cabinet: cabinet description.

Incoming cables/busbar: size and origin.

Main disconnector: "main switch", "hoofskakelaar" and danger notice.

Local disconnector: "local switch", "plaaslike skakelaar" and danger notice.

Fuses and combination fuse switches: circuit designation and fuse rating.

Circuit breakers: circuit designation and overcurrent adjustment where applicable.

Earth leakage protection units: circuit designations.

Contactors, relays, time-switches, timers, control fuses, etc: designation of control circuit and circuits controlled, function and fuse ratings.

Push buttons: circuit designation and function.

Indicating lamps: circuit designation and condition.

Instruments and selector switches: circuit designation and phase colour.

Meters (kVA and/or kWh): circuit designation and phase colours where applicable, reading description, and a single multiplication factor for each reading.

Terminal blocks: terminal designations and function.

Current transformers: ratios and terminal designations.

E2.2.4.21 LEGEND CARDS FOR DISTRIBUTION BOARDS)

3.1 Install an index card in a holder, with a 2 mm thick transparent acrylic panel, screwed or welded inside a door, or where no doors are fitted, to the front plate of the cabinet. The legend card shall list the outgoing circuit designations in accordance with the layout and schematic drawings, functions and outlet locations.

E2.2.4.22 EARTHING

General

Bond and earth the services installation and extraneous conductive parts. The design and installation of an earth electrode shall be in accordance with the relevant codes and specifications. The services installation shall be bonded by means of earth conductors to the earth electrode via the earth bar.

Earth Electrode

Array of Earth Rods

Earth rods shall be at least 16mm diameter and at least 1,5m long and shall be of solid copper. Install each earth rod in a pre-drilled 50mm diameter hole. Fill with mud slurry after installation.

An array of earth rods shall be interconnected with 70mm² bare, stranded copper conductors buried 700mm underground. The earth rods shall be spaced at least 1,5m apart and not less than the depth of the rods below final ground level.

Unless otherwise noted, the array of earth rods shall consist of five rods, four in the form of a 3m square with a fifth in the centre. The interconnections shall form the sides of the square and shall form a cross thus connecting the centre earth rod.

Trench Earths

Trench earths shall comprise 70mm² bare, stranded copper conductors buried underground at a depth of a least 700mm below finished ground level.

Unless otherwise noted the trench earth shall comprise conductors extending 50m in four directions at right angles to each other, and connected at the centre.

Earth Mat

An earth mat shall comprise 70mm² bare, stranded copper conductors buried underground at a depth of at least 700mm below finished ground level in the form of a flat spiral of 24 turns spaced 25mm from each other thus approximate a circle of 1,75m diameter.

Earth Bar

3.1 Provide an earth bar in each LV switchroom for the bonding of the earth electrode, main distribution board earth bar, water mains, any Supplier's earth terminal, any transformer's neutral terminal and tank earth terminal and any HV switchgear frame.

The earth bar shall comprise a 50mm x 6,3mm copper section 500mm long with pre-drilled 10mm holes for connection bolts. Mount the earth bar in the cable trench on spacers away from the wall.

Connect the earth conductors to the earth bar by means of soldered or crimped lugs and 10mm diameter cadmium-plated steel bolts.

The earth conductors to the earth bar from the main distribution board, earth electrode, water mains, and transformer tank shall comprise 70mm² bare stranded copper conductor. The earth conductor to any transformer's neutral terminal shall comprise a 70mm² PVC-insulated copper conductor.

Earth Continuity

Provide earth continuity conductors to earth outlet and each metallic appliance and luminare.

The earth continuity conductors shall be separate bare or green PVC-insulated copper conductors when associated with wiring in wireways.

2,5mm² Earth continuity conductors shall be green/yellow PVC-insulated.

With a multi-core cable circuit, the earth continuity conductor may be a separate core of a multi-core cable identified with green sleeves at each end.

Where earth continuity conductors are looped between outlets the looped ends shall be twisted and ferruled without breaking the electrical or mechanical continuity of the earth conductor.

Bonding

Bond the water main to the earth bar where non-metallic pipes are used and connect the water meter and valves to the earth bar.

Bond metallic cold and hot water pipes, waste pipes, sanitary appliances, ventilation pipes and ducts by means of 12mm x 0,8mm solid or perforatcopper tape (not wire) clamped by means of brass screws and nuts.

Bond metallic roofs, gutters and downpipes to earth by means of 12mm x 0,8mm solid or perforated copper tape clamped by means of galvanised bolts and nuts.

Do not use self-tapping screws for any earthing or bonding functions.

Complete bonding work before painting.

Route copper bonding conductors on the outside of the building in securely fixed galvanised pipe from 2 000mm above ground level to 300mm below ground level.

Testing

Measure the resistance between the earth electrode and the mass of the earth by one of the methods described in the relevant codes and specifications.

Test the earth and bonding continuity in accordance with the Wiring Code.

Submit all test results to the Engineer in a written report before any permanent paving is provided over the earth electrode.

Earthing Of Fences

Earth the fence of outdoor transformer and/or switchgear installations by means of a 70mm² bare, stranded copper conductor 400mm below ground level and 500mm outside the fence around the whole perimeter of the fence. At each corner, bond the perimeter conductor to the fence pole and to a 1,8m earth rod by means of a 70mm² bare, stranded copper conductor.

Bond the perimeter conductor to the main earth bar by means of a 70mm² bare, stranded copper conductor.

E2.2.4.23 WIREWAYS

General

Metallic wireways shall be electrically continuous and the maximum resistance between any two parts shall not exceed 1 ohm.

Wireways shall be mechanically continuous providing a degree of protection of at least IP3 X (that is providing protection against the entry of solid objects exceeding 2,5 mm diameter).

Unless otherwise required conduit installations shall provide a degree of protection of IP44, that is dust and splashproof. Exterior conduit installations shall provide a degree of protection of IPW65 (that is dust-tight, and hose and weather proof).

Where cabling is to be installed afterwards by others, provide galvanised steel draw wires in the wireways.

Space metallic wireways at least 160 mm and non-metallic wireways at least 300 mm away from gas, steam, hot water or similar piping. Prevent wireways from contacting piping so as to avoid electrolytic corrosion.

Conduit

General

No conduit shall be smaller than 20 mm diameter.

Types of Conduit and Applications

BLACK ENAMELLED STEEL CONDUIT

Black enamelled steel conduit shall comply with the relevant codes and specifications for both screwed metal conduit and plain ended metallic conduit. Black enamelled steel conduits may generally be used except:-

a) where exposed to the weather

b) where cast into concrete slabs in contact with the soil

c) where exposed to damp or corrosive environments

d) where "U" traps are formed

e) within 50 km of the coast

f) in kitchen and boiler rooms (in which locations galvanised steel shall be installed)

g) in animal houses

h) where protecting underground earthing conductors.

i) in plenums containing humidified air.

GALVANISED STEEL CONDUIT

Galvanised steel conduit shall comply with the relevant codes and specifications screwed metal conduit and plain ended metallic conduit and shall be hot dip galvanised to the relevant codes and specifications.

PVC CONDUIT

PVC conduit shall comply with the relevant codes and specifications and shall be installed strictly in accordance with manufacturer's recommendations. All PVC conduit and associated fittings and accessories shall be of one manufacture.

PVC conduit may only be used strictly in accordance with SANS 0142 and where:-

a) specifically noted or permitted by the Engineer,
b) not exposed to temperatures in excess of 50°,
c) not exposed to mechanical damage, and
d) not used to support any loads.

FLEXIBLE CONDUIT

Flexible conduit shall comply with the relevant codes and specifications and shall be constructed of metal-reinforced self-extinguishing plastic metallic flexible conduit with a sheath of self-extinguishing plastic. The internal diameter shall not be less than 15 mm. Flexible conduit connectors shall securely grip the conduit and be manufactured of zinc, or cadmium Plated steel, or brass.

Where flexible conduit is run in ceiling spaces which form air conditioning plenums, the flexible conduit shall be of galvanised, corrugated steel construction with no PVC components.

Flexible conduit shall terminate on a conduit box unless a draw box exists within 2 metres.

Installation of Conduit

GENERAL

The interior surface of conduits shall have no sharp protrusions. Fit brass bushes to steel conduit ends. Bond metallic conduit installations to earth and ensure earth continuity not exceeding 1 ohm. Fit lock nuts to running joints. Swab conduit cast into concrete to remove all traces of moisture.

Plug open conduit ends and exclude ingress of dirt and moisture.

CONCEALED CONDUIT

Unless otherwise specified, conduits shall be concealed by being cast into concrete or built into brick or blockwork as applicable. Chasing may only be carried out with the express permission of the Engineer and builder.

Route conduits in structural concrete as close as possible to the neutral axis and secure the conduits against movement.

SURFACE MOUNTED CONDUIT

Where surface mounted conduit is specified, it shall be fixed with spacer bar saddles. The maximum distance between saddles shall not exceed 2 m for steel conduit and 1 m for PVC conduit. A saddle shall be installed within 100 mm of a conduit box.

Remove labels from surface mounted conduit.

ROUTING OF CONDUIT

Conduit in roof spaces, ceiling voids and exposed areas shall be routed parallel and at right angles to structural elements with no diagonal routing.

Wherever possible, conduits shall be run in straight lines with easy curves and shall be drained. Manufactured bends except for 50 mm diameter conduit, and joints at bends, shall be avoided. The minimum radius of a bend shall be four times the conduit diameter.

TERMINATIONS OF CONDUIT

Terminate conduits to luminaires, appliances, conduit boxes and bonding trays as follows:-

a) Concealed Steel Conduit:

i) with two locknuts and a brass bush, or,

ii) with one locknut and a brass bush nut.

b) Surface mounted Steel Conduit:

With a coupling on the outside and a locknut and a brass bush or a brass bush nut on the inside.

c) PVC Conduit:

With a PVC threaded adapter and lock nut with no stress on termination.

CORROSION PROTECTION OF CONDUIT

Paint exposed running threads of black-enamelled steel conduit to be cast or built in with two coats of red lead primer or lap with PVC-insulation tape.

Paint exposed running threads of galvanised steel conduit with two coats of zinc-rich paint.

Provide at least 25 mm of cover to conduits cast into concrete.

Where the paintwork of black-enamelled steel conduit is damaged, prepare the surface and apply two coats of zinc-chromate primer.

Where the galvanising of galvanised steel conduit is damaged, prepare the surface and apply two coats of zinc-rich paint.

FUTURE EXTENSIONS

Provide galvanised steel conduit where future extensions are required. In roof spaces, terminate conduit stubs 40 mm above tie beams and where 900 mm clearance exists.

In concrete terminate conduit 150 mm beyond the concrete in the required direction and provide a draw box within 2 metres. Thread conduit ends and screw on a coupling and brass plug.

Where conduits are exposed, prepare the surface and apply two coats of calcium plumbate primer.

Conduit Boxes

General

Conduit boxes and their cover plates shall comply with the relevant codes and specifications as applicable. Strong mounting lugs and sufficient conduit knockouts shall be provided.

Metallic conduit boxes may be malleable iron or pressed steel and shall be galvanised where used with galvanised steel or PVC conduit.

Where conduit boxes are installed on the exterior they shall be galvanised, primed and painted steel, or malleable iron, or of suitable non-metallic construction and shall be dust, hose and weatherproof to IP65.

Where the temperature may exceed 60°C, for instance where incandescent or other luminaires are mounted against an outlet box, ordinary PVC boxes shall not be installed but steel, or heat-resistant non-metallic boxes shall be installed.

Blank Cover Plates

Fit blank cover plates to draw boxes and unused outlet boxes

The finish of blank cover plates to wall-mounted boxes shall match that of switch and socket outlet plates.

Install cover plates to ceiling-mounted boxes accurately flush with the ceiling and before painting of ceilings.

Install suitable brass cover plates to floor-mounted boxes accurately flush with the floor finish. The brass cover plates shall be sufficiently thick and reinforced to be rigid, shall be secured with countersunk brass screws and shall be sealed with gasket

Fit non-metallic cover plates with nylon screws to PVC conduit boxes.

Where boxes have been installed with fixing lugs below the finished wall surface fit spacers of coiled steel wire or of pipe as necessary.

Draw Boxes

Provide draw boxes to facilitate the drawing in of cables and particularly: -

1) after 180° of bends, and

2) after every 15m of straight runs.

Locate draw boxes to avoid spoiling the appearance of the building. The location of draw boxes shall be accepted by the Engineer.

Where several conduits on the same route require draw boxes a single, large draw box shall be provided.

Expansion Joints

Ascertain the location of structural expansion joints and install conduit expansion joints where conduits have to cross structural expansion joints.

The conduit expansion joints shall be arranged with a draw box as shown on the attached drawing.

Where several conduits on the same route cross a structural expansion joint a single, large draw box shall be provided.

The gap between the inner conduit and outer conduit sleeve shall be sealed with a suitable sealing compound.

Conduit Boxes related to Architectural Features

Where conduit boxes are to be mounted on wall or ceiling panels, tiled surfaces, panelling or other finishes, ensure that such boxes are installed symmetrically. Measure and co-ordinate such positions on site. It will not be sufficient to scale such positions off the drawings.

Where several outlets are close to each other, space them evenly and align them.

Trunking

General

Metallic trunking shall comply with the relevant codes and specifications. Steel trunking shall be manufactured of at least 1,6 mm thick steel and galvanised to the relevant codes and specifications as appropriate.

Where painting is required, prepare, apply a calcium plumbate primer and apply two coats of high gloss enamel paint, or apply a powder coating. All the painting shall be done in accordance with the relevant codes and specifications.

Where steel trunking is cut to length on site, render the edges smooth, prepare the surface, apply two coats of zinc-rich paint, and if painted, reinstate the paint system.

Light steel trunking may only be installed where specified and shall be manufactured of are least 0,8 mm thick steel epoxy polyester powder coated to the relevant codes and specifications.

Unless otherwise specified, provide bridges of 32 mm dia. conduit for each compartment between trunking routes and between trunking and distribution boards, telephone and communications panels.

Aluminium trunking shall be anodised to the relevant codes and specifications.

Installation

Install trunking complete with end caps, outlets, internal splices, covers, internal partitions, 2 clips, knockouts, adaptors, cable retainers, suspension rods, fixings, brackets, clamps, hangers, nuts, bolts, washers, screws and all other accessories required to complete the installation.

Install cable retainers at spacings of not more than 1 metre.

At changes of direction (elbows, tees, cross-overs, etc.), provide internal splices and exterior covers to present a smooth appearance.

Snap-in covers may be used on trunking up to 70 mm wide. Trunking wider than 70 mm shall be fitted with machine screws secured with retained nuts at sufficient points to prevent distortion of the cover.

Support trunking to prevent deflection beyond 1/180th of the span or beyond 3 mm whichever is the lesser.

Provide partitions to separate different services as required.

Power Skirting

Power skirting shall have 3 partitioned compartments unless otherwise specified.

Power skirting shall allow access to the telephone compartment without any danger of contact with live parts.

Provide cabling throughout power skirting and with sufficient slack to facilitate the addition and repositioning of outlets.

Powerskirting shall be finished in the scheduled colour.

Underfloor Ducting

Underfloor ducting shall have 3 partitioned compartments unless otherwise specified. Outlets shall allow access to the telephone compartment without any danger of contact with live parts.

Samples, shop drawings and complete technical literature with approvals, shall be submitted to the Engineer.

Install the underfloor ducting within an accuracy of ± 12 mm from the positions shown on the drawings. Prepare dimensioned "as-built" drawings of the installation.

Install the underfloor ducting complete with elbows, tees, cross-overs, outlets, outlet pedestals, end caps, adapters, fixings, and all other accessories required to complete the installation.

Provide cabling throughout underfloor ducting and with sufficient slack to facilitate the addition and repositioning of outlets.

The installation shall provide a degree of protection of IP 67 (that is dust and watertight) to IEC Publication 162 and be watertight to 12 mm water gauge.

Building Elements as Wireways

With the express approval of the Engineer, suitable building elements, such as hollow mullions may be used as wireways provided that:-

a) the wiring is not exposed,

b) metallic building elements are bonded to earth,

c) the building elements are non-inflammable or self-extinguishing, and

d) rewireability is facilitated.

E2.2.4.24 CIRCUITRY

Minimum Sizes

The following minimum wiring and cable sizes apply, unless otherwise specified:-

(i) PVC-insulated wiring and cabling for single-phase power and lighting - 2,5mm²

(ii) PVC-insulated wiring and cabling for signal, control, alarm and communication - 1,5mm²

(iii) PVC/PVC/SWA/PVC cabling for three-phase circuits - 1,5mm²

Neutral Conductor

A neutral conductor, equal in size to the phase conductors shall be run to each three-phase outlet and appliance unless otherwise specified.

Segregation of Circuits

Separate wireways, or separate compartments of multi-compartment wireways shall be provided for the following circuits: -

1) normal power and lighting circuits
2) emergency power and lighting circuits

3) standby power and lighting circuits

4) low voltage (50 V to 1 000 V) control, instrument, signal and alarm circuits

5) extra low voltage (up to 50 V) control, instrument, signal, alarm, fire detection, intercommunication circuits

Identification Colours

The following colours shall be used to identify wiring and cable cores:-

Description	**Colour**
Red phase of 3-phase circuits	red
White phase of 3-phase circuits	white
Blue phase of 3-phase circuits	blue
Live of single-phase circuits	red
Neutral	black
Earth	green/yellow
Alarm circuits	orange
AC control circuits	red
DC control circuits	blue
Neutral	black
Instruments	grey

Three-phase circuits shall be terminated with the red phase on the left, white phase central and blue phase on the right viewed from the front of the switchgear.

E2.2.4.25 CABLE TRAYS AND LADDERS

General

Steel cable trays and ladders shall be galvanised.

Where painting is required, apply a calcium plumbate primer to SANS 912:1972 and apply two coats of high gloss enamel paint to SANS 630:1972, or apply an epoxy-polyester powder coating to SANS 1274:1979.

Cable trays and ladders and their accessories shall be pre-manufactured. On site fabrication will not be allowed without the express permission of the Engineer. Where standard lengths are cut on site, render smooth the cut edges, prepare the surface, apply two coats of zinc-rich paint and if painted, reinstate the paint system.

Installation

Install cable trays and ladders complete with cross-overs, tees, reducers, bends, elbows, cornices, splices, traying arms, fixings, brackets, "unistruts", clamps, hangers, nuts, bolts, washers, screws and all other accessories required to complete the installation.
Support cable trays and ladders to prevent sagging beyond 1/180th of the span or 3mm whichever is the lesser. Each length shall be supported in at least two places along the length. The diameter of expanding bolts, studs, etc., and nuts, bolts and patent fixings, etc., securing the trays and ladders shall not be less than 10mm.

Heavy Duty Cable Ladders

Cable ladders unless otherwise specified, shall be heavy duty manufactured of sheet steel at least 2,0mm thick with shoulders at least 76mm high. Cable ladders and accessories shall be hot-dip galvanised to SANS 763:1977.

Rungs shall be spaced at intervals not greater than 300mm. Bends, tees, elbows, cross-overs and reducers shall have minimum radii of 450mm.

Support cable ladders on traying arms, GKN P2231/2232/2233/2234 or approved alternative of length to suit ladder width and fitted with end caps.

Cable ladder lengths over 3m shall be supported in at least three places along the length.

Bolts, nuts and washers securing splice pieces shall be at least 6mm diameter.

Where cable ladders ramp slightly so that a bend is not required provide hinged splice pieces hinging on 8mm nuts, bolts and washers and with radiused corners.

Light Duty Cable Ladders

Light duty cable ladders may only be installed where specified or where expressly permitted by the Engineer. These cable ladders shall be manufactured of sheet steel with shoulders comprising 41,3mm x 10mm x 1,6mm pressed steel channels. Cable ladders and accessories shall be hot dip galvanised to SANS 763:1977. Rungs shall be spaced at intervals not greater than 300mm. Bends, tees, elbows, cross-overs and reducers shall have minimum radii of 300mm. Support cable ladders on traying arms GKN or approved alternative of length to suit ladder width and fitted with end caps. Cable ladder lengths over 3m shall be supported in at least 3 places along the length. Changes of direction shall be undertaken with manufactured elbows hinged horizontal splices or hinged vertical splices. Bolts, nuts and washers securing splices shall be at least 10mm diameter.

The hinge pin of the hinged horizontal splice shall be at least 8mm diameter.

Hinged horizontal or vertical splices may be used for elbows and bends up to 45°. Manufactured elbows and bends shall be used for elbows and bends over 45°.

Light duty cable ladders shall be GKN H41/10 or approved alternative.

Heavy Duty Cable Trays

Cable trays, unless otherwise specified, shall be heavy duty manufactured from perforated sheet steel at least 2,5mm thick with shoulders at least 76mm high. Heavy duty cable tray and accessories shall be hot-dip galvanised to SANS 763:1977.

Provide cornices at changes of direction to allow minimum bending radii of cables.

Support heavy duty cable trays on traying arms, GKN P2231/2232/2233/2234, or approved alternative of length to suit tray width and fitted with end caps.

Light Duty Cable Tray

Light duty cable trays may only be installed where specified or where expressly permitted by the Engineer and shall be manufactured from perforated sheet steel at least 1,2mm thick with shoulders at least 19mm high. Light duty cable trays and accessories shall be galvanised to SANS 934:1969 heavy class.

Provide cornices at changes of direction to allow minimum bending radii of cables.

Support light duty cable trays on traying arms, GKN P2491/2492/2494/2495/2497/2500 or approved alternative of length to suit tray width.

E2.2.4.26 ACCESSORIES: LIGHT SWITCHES AND SOCKET OUTLETS

Light Switches

General

Wall switches shall comply with SANS and bear the SABS mark and shall be of the tumbler-operated microgap type. Submit samples to the Engineer for approval.

Wall switches shall be rated for 230V 16A. Install wall switches with the centre 1 400mm above finished floor level

Switch boxes and cover plates shall comply with SANS 1085 and SANS 1084.

Multiple switches may be allowed only if the switches control the same circuit. Switches controlling separate circuits on different phases shall be installed in separate boxes.

Switch toggles or rockers shall operate in a vertical direction.

Where indicating lights are specified, they shall form an integral part of the switch and shall have neon lamps or light-emitting diodes.

Light switches shall be finished as scheduled.

Metallic switch plates shall be secured with two chromium plated countersunk screws. Non-metallic switch plates shall be secured with two nylon countersunk screws.

Flush Wall Switches

Where conduit is routed flush, install flush wall switches built into conduit boxes.

Surface-mounted Flush-Pattern Switches

Where flush-pattern switches are to be mounted on the surface they shall be mounted in 100mm x 50mm or 100mm x 100mm by 35mm deep extension boxes.

Industrial Surface-mounted Switches

The box and cover plate shall be constructed of steel fitting together to make a dustproof assembly, IP44 to IEC Publication 162. The switch toggle or rocker shall be shrouded where it protrudes through the cover plate.

Where required, dustproof industrial surface-mounted switches shall incorporate hinged and sprung dust-proof flaps over the switches.

Hose-proof Switches

Switches designated hose-proof, weather-proof or waterproof shall be of non-metallic construction and hose-proof to IPW65 of IEC Publication 162. Operation may be rotary, or rocker through a membrane.

Ceiling Switches

Ceiling switches shall be rated for 250V 10A amp shall be installed on a round conduit box. The base shall be bakelite and the cover of bakelite with a brass screw ring insert.

Provide a 1,25m length of nylon cord.

Socket Outlets

General

Socket outlets shall comply with SANS 164,SANS10142-1: 2017 and bear the SANS mark or with SANS 1239 and IEC 309 as applicable. All socket outlets shall be earth leakage protected. Submit samples to the Engineer for approval.

Unless otherwise specified, socket outlets shall be rated for 250V (phase to neutral) 16A, shall be switched and have safety shutters on the phase and neutral contact tubes.

Where indicating lights are specified they shall form an integral part of the socket outlet and shall have neon lamps or light-emitting diodes.

Install socket outlets with the centres at the following heights above finished floor level unless otherwise noted:-

(a) generally unless otherwise specified : 300mm

(b) hospitals, clinics etc. : 450mm

c) kitchens, laboratories, industrial areas, plant rooms and over work tops : 1 200mm Socket outlets shall be finished as scheduled.

Metallic socket outlet plates shall be secured with two countersunk chromium-plated screws. Non-metallic plates shall be secured with two countersunk nylon screws.

Flush Single-phase Socket Outlets (16 A)

Flush single phase socket outlets shall be rated for 250V 16A and incorporate three contact tubes. They shall be mounted in 100mm x 100mm conduit boxes.

Surface-mounted Flush-pattern Single-phase Socket Outlets

Where flush-pattern single-phase socket outlets are to be mounted on the surface they shall be mounted in 100mm x 50mm or 100mm x 100mm extension boxes.

Industrial Surface-mounted Single-phase Socket Outlets

The box and cover plate shall be constructed of steel fitting together to make a dust-proof assembly, IP44 to IEC Publication 162. The switch toggle or rocker shall be shrouded where it protrudes through the cover plate. Where required, dust-proof industrial surface-mounted socket outlets shall incorporate hinged and sprung dust proof flaps over the switches and contact tubes.

Moulded Case Circuit Breaker Single-phase Socket Outlets

These socket outlets shall comprise a miniature moulded case circuit breaker and a 250V, 16A 3- contact tube socket outlet mounted in a standard 100mm x 100mm box. The miniature MCCB shall be Heinemann AM1-21, or approved alternative and shall be rated at 10A unless otherwise noted. The assembly shall be Hain catalogue reference SGNY-lO or approved alternative.

Hose-proof Socket Outlets

Socket outlets designated hose-proof, weather-proof or water-proof shall be hose-proof to IPW65 of IEC Publication 162 when the plug is removed and with the plug inserted.

Three-phase Socket Outlets

Three-phase socket outlets shall be of the CEE 17, 400V, 6h pattern with 5 contact tubes for three-phases, neutral and earth. Each outlet shall incorporate a switch which can only operate with the plug inserted. Unless otherwise specified, the outlets shall be rated at 16A.

Stove Connectors

Stove connectors shall be rated for 400/230V, 15A with four contact tubes for three-phases and neutral. Earth continuity shall be provided through the metallic casing of the socket outlet to the metallic casing of the plug by means of a screwing ring.

Stove connectors shall comply with the Appendix referred to in Regulation 707 (13) of the Standard Regulations for the Wiring of Premises.

5A Single-phase Socket Outlets

5A single-phase socket outlets shall be unswitched, rated for 250V, and have 3 contact tubes with shuttered live and neutral tubes. The socket outlets may be mounted in pre-punched trunking, 63mm dia., 100mm x 50mm or 100mm x 100mm conduit boxes.
Shaver Socket Outlets

Shaver socket outlets shall comply with BS 3052 and shall incorporate a double-wound isolating transformer rated at least 20VA and providing 115V and 230V.

The socket contacts shall be suitable for 115V North American pattern plug tops and 230V European pattern plug tops. Insertion of a plug top shall switch on the transformer primary and removal of the plug top shall switch it off.

Overload protection shall be included.

13A Single-phase Socket Outlets

13A single-phase socket outlets shall comply with SANS 1363.

Isolators (Switch Disconnectors) For Building Services Applications

Isolators shall comprise air-break switch disconnectors complying with SANS 152-1977, be double-pole for single-phase circuits and triple-pole for three-phase circuits, and be rated for 433/250V.

The current rating shall be 63A unless otherwise specified.

Isolators for single-phase appliances with loads less than 2,5kVA may have current ratings of 13A.

Where the final connection from the isolator comprises a flexible cord, the isolator assembly shall incorporate an indicating light, a grommet and cord grip or a compression gland, and a fuse rated to protect the cord.

Metallic cover plates shall be secured with two countersunk chromium-plated screws and non-metallic cover plates with two countersunk nylon screws.

The isolators shall be finished as scheduled.

Where indicating lights are specified they shall form an integral part of the isolator assembly and shall have neon lamps or light-emitting diodes.

Isolators up to 63A current rating shall be installed in 100mm x 100mm conduit boxes.

E2.2.4.27 LUMINAIRES

Provide all luminaires listed in the Schedule and shown on the Drawings including procurement, delivery, acceptance, storage, installation, aiming, adjustment, testing and commissioning.

Luminaires shall be installed complete with mounting accessories, brackets, poles, stirrups, baseplates etc.

Excavate, backfill and consolidate as necessary for luminaires.

Luminaires shall include lamps, indicator lamps, control gear, power factor correction equipment, electro-magnetic interference suppression equipment and all other accessories necessary to render the luminaires fully operative.

Luminaires shall not emit electro-magnetic or radio/television interference in excess of the limitations stipulated by the Department/Engineer of Posts and Telecommunications.

Luminaires shall have internal wiring of copper conductors of not less than 0,5mm², with suitable heat-resistant wiring to SANS 529. PVC insulated wire shall not enter luminaires with polycarbonate components. A terminal block shall be fitted to each luminaire. Luminaires shall each have an earth terminal and shall be bonded to earth.

Each luminaire shall be labelled next to the lamp holder and on the control gear with the following information: -

a) voltage rating;
b) lamp type
c) lamp wattage (for incandescent lamps, the maximum wattage).

Control gear shall be power factor corrected to at least 0,9 lagging, shall have a circuit efficiency of not less than 0,85 and shall be silent in operation.

Capacitors shall comply with SANS 1250:1979.

On request of the Engineer, submit luminaire details (including photometric data, and noise level reports) prepared by an accredited laboratory.

On request of the Engineer, remove any luminaire from site and submit luminaire to tests required by Engineer.

Luminaires shall be designed and installed to avoid excessive temperatures. Components and materials shall be so selected that they are not adversely affected by the operating temperature.

The harmonic distortion of a lamp circuit shall not exceed 30%.

Installation

Refer to Section: "Fixing of Materials" of this Specification.

Install luminaires in accordance with the manufacturer's recommendations.

Mount luminaires after the first coat of paint has been applied. Await final coat of paint, before completing installation of luminaires.

Fix luminaires equal to or narrower than 225mm at the centre and two outer positions. Fix luminaires wider than 225mm at the centre and at the four corners.

Where luminaires butt, fix them together with brass bushes and lock nuts.

Screw conduits directly to exterior luminaires and to luminaires with a degree of protection in excess of IP44. Provide gasketting and sealants between luminaires and surface to which they are mounted. For wall-mounted luminaires, the conduit shall enter the luminaire at a slight downward angle to the horizontal.

Where luminaires are mounted on, or in, ceilings made of panels, mount the luminaires symmetrically. Where the mass of the luminaires exceeds the load carrying capability of the ceiling systems, install suitable hangers.

Connections to luminaires mounted on or in ceilings shall comprise metallic conduit, flexible conduit (without a PVC sheath), or silicone rubber flexible cord. Co-ordinate such connections with the Contractors installing the ceiling, air conditioning and other services.

Exterior Luminaires

Exterior luminaires shall have a degree of protection of at least IP65 of IEC-162. Lenses shall be resistant to degradation and discolouration from ultra-violet radiation. Materials shall be corrosion-resistant and selected to avoid electrolytic corrosion. Luminaires constructed of sheet steel or sheet aluminium are not acceptable.

The bodies shall be painted cast-iron; painted, or anodised (Class C), die-cast LM6 aluminium; glass-reinforced polyester; or polycarbonate.

Gaskets shall be silicone rubber or neoprene.

Lenses shall be polycarbonate or heat-resistant glass. Lens, or lens-frame, securing screws shall be stainless steel.

Floodlight luminaires shall incorporate calibrated horizontal and vertical angle scales.

Emergency and Standby Luminaires

Emergency Fluorescent Luminaires (with integral battery)

Each emergency fluorescent luminaire with integral battery shall incorporate a mains-failure relay, battery charger, nickel cadmium battery, and inverter which shall provide emergency lighting by means of one lamp operating at 100% light output for at least one hour. The battery charger shall fully recharge the batteries within 24 hours.

Mercury Vapour Luminaires on Emergency and Standby Circuits

Each mercury vapour luminaire on an emergency or standby circuit shall incorporate a mains failure relay, change-over switchgear, a photo switch and quartz halogen lamp. The quartz halogen lamp shall operate on mains failure until the mercury vapour lamp has run up when the photoswitch shall extinguish the quartz-halogen lamp.

High-pressure Sodium Luminaires on Emergency and Standby Circuits

Each high-pressure sodium luminaire on an emergency or standby circuit shall have a lamp with a run up time of not less than 20 seconds.

Exit Signs

Each exit sign with integral battery shall incorporate two fluorescent lamps each with its own separate control gear, mains failure relay, battery charger, nickel cadmium battery and inverter which shall provide emergency lighting by means of one lamp operating at 100% light output for at least one hour. The battery charger shall fully recharge the batteries within 24 hours.

Exit sign lettering shall be at least 150mm high.

Exit signs shall comply with BS 5266 and BS 2560. Surface-mounted exit signs shall incorporate an aperture of at least 200mm x 50mm with prismatic diffuser to provide downward light.

Fluorescent Luminaires

General

Interior fluorescent luminaires shall comply with SANS 1119:1976.

Construction

Provide three 20mm diameter knockouts in the backplate, one in the centre andone at each end. Each knockout shall have accompanying slots for screws to fit a standard round conduit box and arranged so that the luminaire can be turned through an angle of 90°C. The backplate shall extend the entire length of the luminaire. Luminaires shall be so constructed that it is possible to reach the control gear without disconnecting any wiring and without removing the luminaire from its installed position.

Channel Luminaires

Fluorescent channel luminaires shall consist of a ventilated rectangular wiring channel.

Lenses. Diffusers and Louvres

Lenses, diffusers and louvres shall be sufficiently strong and rigid to resist distortion and breakage during normal operation and maintenance.

Lenses, diffusers and louvres shall be constructed of:

a) flame-retardant acrylic (methacrylate),

b) flame-retardant, UV and light stabilised polystyrene, or
c) UV and light stabilised polycarbonate.

Components

Ballasts shall comply with SANS 890:1967. Unless otherwise specified ballasts shall be switch-start. Switch-start ballasts shall be wound length-wise around pre-assembled laminations crimped into a steel channel. No compound shall be required.

Starters shall comply with BS 3772/IEC-55 and be accessible for replacement with the lamps in position.

Lamp holders shall be telescopic or hinged sprung-ratchet.

Lamps

Lamps shall comply with SANS 1041:1975. Lamps shall have an average life of at least 7 500 hours on a 3 hour on/off switching cycle. On request submit to the Engineer the light output of the lamps at 100 hours and 2000 hours. The light output at 2 000 hours shall not be less than 80% of the output at 100 hours.

No lamp flicker of lamps shall be visible under normal operation after initial stabilisation period of 100 hours. Lamp colour shall be SANS colour reference 2 unless otherwise specified. 18W, 36W, and 58W fluorescent lamps (26mm diameter) shall be "colour 84" unless otherwise specified.

Incandescent Luminaires

Lamp holders shall be porcelain.

Lamp holders for lamps of 150W and higher rating shall be Edison Screw (E.S.).

The operating temperature within the luminaires shall be limited to avoid any adverse effects on any components.

Gas-Discharge Luminaires

Ballasts shall comply with SANS 1266:1979. Ballasts shall be cast in epoxy-resin and provided with heat sinks, cooling fins, etc., to limit the operating temperature to avoid any adverse affects to any components.

Interior luminaires shall comply with SANS 1278:1980.

Mercury vapour lamps shall be of the colour corrected, high pressure, fluorescent type.

High pressure sodium vapour lamps shall be of the colour enhanced type.

E2.2.4.28 ENERGISING LV ELECTRICAL MOTORS

Before energising any of the motors, for the purpose of commissioning, the Contractor shall measure the insulation resistance of each motor between phases and to casings by means of a 500 Volt "Megger" instrument, and the values shall be recorded and forwarded to the Engineer for information. If any of the readings for a particular motor are lower than 1,5 megohms, that motor shall not be energised until it has been dried out by the Contractor by a method to the Engineer's prior approval. Unless the lowest of the insulation resistance measurements on that motor exceeds 1,5 megohms, the motor shall not be energised.

The method adopted for drying-out shall be by applying heat, preferably by circulating current through the windings or, alternatively, by means of space heaters located in and around the machine.

Insulation resistance measurements and temperature readings shall be taken regularly every half hour at the start of dry-out until the motor attains an even temperature and thereafter every hour. The characteristic dry-out curve of insulation resistance versus temperature shall be plotted and dry-out may be considered

complete four hours after the resistance readings have started to rise from the steady minimum value, providing that the winding temperatures have remained steady during this period.

All equipment and the personnel required for the drying-out operation, shall be provided by the Contractor. The onus remains on the Contractor to satisfy himself that a motor is dry before it is connected to the supply. Any motor which fails as a result of being commissioned in a damp condition, shall be repaired free of charge by the Contractor.

ANNEXURE A TECHNICAL DATA SHEETS AND PARTICULARS

FOR EACH LISTED ITEM THE CONTRACTOR WILL GIVE THE FOLLOWING DATA

ELECTRICAL EQUIPMENT OFFERED

Item	Offered
1.1) Motor Control Centre Steel-work	
Manufacture	
Is the form of Internal Separation 3b, 4a or 4b State?	
MCC Raw Water	
IP rating doors closed	
MCC Filtration	
Type tested or partially type tested to SANS IEC 60439? All supporting certificated of compliance to be supplied with tender	
1.2) Moulded case circuit breakers	
Manufacturer	
Type/model	
In accordance with specification	
1.3) HRS fuse links	
Manufacturer	
Type/model/rating	
In accordance with specification	
1.4) Contactors	
Manufacturer	
Type/model	
In accordance with specification	
1.5) Selector switches	
Manufacturer	
Type/model	
In accordance with specification	
1.6) Pushbuttons	
Manufacturer	
Type/model	
In accordance with specification	
1.7) Relays	
Manufacturer	
Type/model	
In accordance with specification	
Item	**Offered**

1.8) Indicator lights	
Manufacturer	
Type/model	
In accordance with specification	
1.9) Earth leakage relays	
Manufacturer	
Type/model	
In accordance with specification	
1.10) Programmable logic controllers (PLC)	
Manufacturer	
Type/model	
Maximum number of racks	
Program memory non-volatile?	
I/O capacity (digital)	
I/O capacity (analog)	
Communication protocol	
In accordance with specification	
1.11) Emergency stop buttons	
Manufacturer	
Type/model	
In accordance with specification	
1.12) Surge Arrestors	
Manufacturer	
Type/model	
In accordance with specification	
1.13) Soft Starters	
Manufacturer	
Type/model	
Rated current	
Max No. Starts / h	
CLASS	
Control supply voltage [V]	
Type of terminals	
Rated operational voltage(V)	
Number of starts per hour	
Starting voltage	
Ramp-up time	
Relative starting current limit	
Rated operational current (Ie)	
Optional line contactor	
Motor overload protection	
Thermistor motor protection	
Device overload protection	

Motor heating	
Communication module	
Integrated display	
HMI type	
All supporting technical literature to be supplied with tender	
1.14) DC power supplies	
Manufacturer	
Type/model	
In accordance with specification	
Item	**Offered**
1.15) Panel extraction fans	
Manufacturer	
Type/model	
In accordance with specification	
1.16) Conduit	
Manufacturer	
Type	
In accordance with specification	
1.17) Light switches	
Manufacturer	
Type	
In accordance with specification	
1.18) Switch Socket outlets	
Manufacturer	
Type	
In accordance with specification	
1.19) luminaries	
Manufacturer	
Type	
In accordance with specification	
1.20) L.V. armoured cables	
Manufacturer	
Type	
SANS approved	
In accordance with specification	

1.21) Multicore cables	
Manufacturer	
Type	
SANS approved	
In accordance with specification	
1.22) Float switches	
Manufacturer	
Type	
In accordance with specification	
1.23) Cable tray	
Manufacturer	
Type	
Material	
In accordance with specification	
Item	**Offered**
1.24) Telemetry Equipment (if the provided space is not enough attach manufactures spec)	
1.24.1 Remote Terminal Unit (RTU)	
Manufacture	
Model number	
Communication	
Features	
Analog Inputs (AIN)	
Digital Inputs (DIN)	
Digital Outputs (DOT)	
Data Reporting	
Other Specifications	
1.24.2 Digital Input Surge Protector	
Manufacture	
Model Number	
Features	
Supply Voltage DC	
Physical Dimension	
Connection Sockets	

Protection	
Channel (I/O)	
1.24.3 Power Supply	
Manufacture	
Model Number	
DC supply	
AC supply	
Battery supply	
Battery	
Rated Power	
Protection	
1.24.4 Data Radio	
Manufacture	
Model Number	
Transmission Power	
Working Frequency	
Power Consumption	
Receiver Sensitivity	
Working Temperature	
Output/ Input Interface	
Power control	
Circuit Structure	
High Anti-Interference and Low BER (Bit error Rate)	