

## **C3.4.4**

### **STANDARD SPECIFICATIONS FOR ELECTRICAL WORKS (INCLUDING GENERAL WORKS)**

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**PART EA GENERAL SPECIFICATIONS****EA1 DESCRIPTION OF WORK****EA1.1 Related Documents**

The requirements of the General Conditions, Supplementary Conditions, Technical Specifications, and Drawings apply to all Work herein and forms part of the scope of work.

**EA1.2 Scope****EA1.2.1 General Scope****A. Overview**

Provide all labour, materials, tools, machinery, equipment, supplies, transportation, storage, utilities, appliances, hauling, hoisting, excavation, backfill, supervision, and services necessary to complete the Electrical Work under this Contract. Coordinate Work with the Work of the other trades so as to resolve conflicts without impeding job progress.

**B. Drawings and Documentation**

Examine the Architectural, Structural, Mechanical, Plumbing, and Electrical Drawings and other Sections of the Specifications in order to determine the extent of Work required to be completed. Failure to examine all the Contract Documents for this Project will not relieve the Contractors of the responsibility to perform all the Work required for a complete, fully operational, and satisfactory installation.

**C. Project Location**

The Work to be performed under this Contract is in connection with the construction and erection of the electrical installation at Hammarsdale WWTW Development, on behalf of eThekweni Municipality.

**D. Work Included**

The Work includes, but is not limited to, the supply installation and commissioning of material and equipment associated with the following systems, equipment, and services:

**EA1.2.2 Electrical System**

- a. Electrical service provisions, MV distribution network, MV equipment, LV distribution network, LV equipment, distribution boards and small power and lighting systems,
- b. Area lighting, generator system and metering systems
- c. A system of empty conduits and other provisions as required for installation of the telephone, data, fire alarm and security systems.
- d. Conduits and boxes in slabs on or below grade, inaccessible space below slabs above grade, and walls below grade, in cooperation with other trades.
- e. Earthing and lightning protection system.
- f. Testing and commissioning of the full electrical system

**EA1.2.3 Information and Communication Technology (ICT) System**

Described in the Communications and Electronics General Specification

**EA1.2.4 Security System**

None

## **EA2 DESIGN CRITERIA**

### **EA2.1 Quality Assurance**

#### **EA2.1.1 Codes and Standards**

The following codes and ordinances were used in the design of the project and shall be complied with during construction of the project.

- a. The Occupational Health and Safety Act no. 85 of 1993, as revised, whereby SANS 10142 is enclosed.
- b. Government notices.
- c. The Local Government Ordinance 1939 (Ordinance 17 of 1939) as amended and the municipal by-laws and any special requirements of the local supply authority,
- d. The Fire Brigade Services Act 1993, Act 99 of 1987 as amend,
- e. The National Building Regulations and Building Standards Act 1977 (Act 103 of 1977) as emended,
- f. The Post Office Act 1958 (Act 44 of 1958) as amended,
- g. The Electricity Act 1984 (Act 41 of 1984) as amended,
- h. The Regulations of the local Gas Board where applicable.

#### **EA2.1.2 Standards**

Refer to standard specifications for general administrative/procedural requirements related to compliance with applicable standards. This Work and all materials shall meet the standards set forth in the applicable portions of the following recognized standards:

- a. Building Code – SANS 10400
- b. Electrical Wiring Code – SANS 10142
- c. All other relevant SANS Codes

### **EA2.2 Compliance with Standard Specifications**

Except where otherwise specified, the equipment shall comply with the current editions of the relevant specifications of the South African Bureau of Standards and the British Standards Institution or the International Electro Technical Commission recommendations.

### **EA2.3 General Requirements**

#### **EA2.3.1 Safe Design and Standardization**

All equipment supplied and installed under this contract shall be designed:

- a. To prevent any injury to personnel employed on the construction, operation, and maintenance of the plant.
- b. To facilitate inspection, cleaning, and repair of the equipment.
- c. To operate continuously and satisfactorily in the prevailing site conditions.
- d. To be able to withstand without damage such sudden variations of electrical load as may be met under normal working conditions, including short circuits and lightning strikes.
- e. To obviate risks of accidental short-circuits due to animals, birds, and insects.
- f. To avoid pockets in which water can collect in outdoor equipment.
- g. To avoid condensation in closed compartments by the provision of adequate ventilation or where necessary, heaters.
- h. Such that conductors can carry normal load and fault currents without overheating or other damage.

- i. Such that moving parts can be readily lubricated. Grease nipples shall be provided in accessible positions for this purpose.
- j. To be vermin proof.
- k. To be corrosion resistant.

#### **EA2.4 Quality Of Materials and Workmanship**

- a. All materials and equipment for this Contract shall be new and undamaged. Corresponding parts shall be interchangeable.
- b. Where so directed by the specification or by the Engineer, the Contractor shall provide samples and test certificates of materials for approval.
- c. The labour used by the Contractor shall at all times be adequately qualified and experienced for the particular task.

#### **EA2.5 Fixings and Connections**

##### **A. Nuts and Bolts**

Metric size nuts and bolts shall be used unless otherwise specified. Each bolt or stud shall project at least one thread but not more than 6 mm from the nut. Special spanners shall be provided where nuts and bolts are not easily accessible. The nuts on the moving plant or plant subject to vibration shall be fixed by means of locknuts, "Loctite" or other approved locking method. Bolts and studs shall be adequately sized to carry the loads, which may be imposed on them.

##### **B. Materials of Nuts and Bolts**

Only stainless-steel nuts, bolts and washers shall be used for all electrical connections.

#### **EA2.6 Non-Corroding Materials**

- A. Non-corroding materials shall be used in the construction of outdoor equipment and plant. This includes all cable racks, trays, and clips.
- B. The permissible grades and alloys are as follows:
  - a. Stainless Steel: Grade 316 or better
  - b. Extruded Aluminium: 6082-T6
  - c. Cast Aluminium: L-2520
  - d. Glass fibre: To the relevant SANS specification

#### **EA2.7 Galvanising And Painting**

- A. NO drilling, cutting, bending, punching, welding, and forming of the steel or any surface damage shall be allowed after galvanising or painting.
- B. All the steel work shall be prepared, hot dipped galvanised and painted using the processes as per manufacturers recommendations.

### **EA3 EARTHING AND LIGHTNING PROTECTION**

#### **EA3.1 Quality Assurance**

##### **EA3.1.1 Codes and Standards**

The earthing and lightning protection shall comply fully with the applicable SANS specifications as set out below and all equipment shall bear the mark of approval of the South African Bureau of Standards.

- a. The latest issue of SANS 10313: Protection against lightning - Physical damage to structures and life hazard Requirements of surge protective devices
- b. The latest issue of SANS 61312: Requirements of surge protective devices
- c. The latest issue of SANS 62305: Protection against lightning
- d. The latest issue of SANS 10292: Earthing of low-voltage (LV) distribution systems.
- e. The latest issue of SANS 10199: The design and installation of earth electrodes
- f. The latest issue of NRS076: Earthing of distribution substations with nominal voltages up to and including 132 kV.

#### EA3.1.2 Manufacturers

If they comply with the specifications and requirements, as listed in this section, will be acceptable.

#### EA3.1.3 Installers

The electrical contract shall appoint a specialist Earthing and Lightning Protection Contractor to design and install the earthing and lightning protection system. The specialist installer must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

### EA3.2 **Scope Of Works**

The specialist contractor shall:

- a. Carry out earth resistivity tests on the site of works and provide a test results certificate together with recommendations of the installation to the Engineer.
- b. Once approved, Supervise the installation in compliance with SANS requirements.
- c. Carry out interim earthing tests and if below required value, improve on earthing installation until earthing values are achieved.
- d. Provide as-built drawings of the complete earthing and lightning protection system.
- e. Provide test certificates and a sign-off certificate of the completed earthing and lightning protection system.

### EA3.3 **Design Criteria**

- a. A provisional earthing and lightning protection system is indicated on the drawings and measured in the Bill of Quantities. The earthing system shall follow the same trench and rod system as indicated on the drawings.
- b. Earthing shall be installed in trenches of 600mm deep below finished ground level (FGL)
- c. The tops of the earth rods shall be no less than 600mm below FGL with rods installed vertically. If this is not achievable, then rods should be installed in a horizontal position and indicated on as-built drawings.
- d. Final measures will be based on installed quantities up to the Bill measured values only. Material above bill measured quantities shall be approved by the Engineer prior to installation.

### EA3.4 **Earthing of Substations**

- a. All substations shall be earthed in accordance with the requirements of the supply authority. If no earthing is specified and no specific requirements of the supply authority exist, the following method shall be adopted.

- b. A main earth bar (minimum cross-sectional area 50 mm x 6 mm and of HDHC copper) must be provided and fixed to the high voltage room wall by means of shock proof insulators. Suitable space shall be provided between the earth bar and the wall.
- c. All earth wires shall be secured to the earth bar by means of 10 mm diameter brass bolts. Lock nuts shall be provided for all terminals.
- d. The following connections shall be made from this earth bar system:
  - 70 mm<sup>2</sup> insulated stranded conductor to the transformer neutral.
  - Copper tape to the transformer tank.
  - 70 mm<sup>2</sup> bare copper earth conductor to MV switchgear earth bar.
  - 70 mm<sup>2</sup> copper earth conductor to switchgear frame and board.
  - 2 x 70 mm<sup>2</sup> bare copper earth conductors to earth mat/earth rods.
- e. Where necessary, earth connections shall be protected against mechanical damage and corrosion.
- f. Two earth rods shall be driven into the ground in the immediate vicinity of the substation at least 3m apart with their tops not less than 600 mm below ground level. The rods shall be interconnected with a 70 mm<sup>2</sup> bare copper conductor buried at a depth of not less than 750 mm. A 70 mm<sup>2</sup> earth conductor shall be taken from each of the two earth rods to the main earthing bar in the high voltage room.

### **EA3.5 Earthing of Switch Rooms**

The earthing of switch rooms shall conform to the earthing requirements of substations as described above.

### **EA3.6 Earthing of Outdoor Equipment**

In cases where substations contain transformers or switchgear installed outdoors, the compulsory fence, if no other method is specified, shall be earthed as follows:

- a. A 70 mm<sup>2</sup> earth conductor shall be installed 400 mm below ground level and 500 mm from the fence on the outside of the substation along the entire perimeter of the fence. This earth conductor shall be earthed at each corner by means of a 1,8m earth rod and the rod and earth conductor bonded to the fence.
- b. The earth conductor shall be bonded, at least at two points, to the main earthing system.
- c. A 70 mm<sup>2</sup> earth conductor shall also be buried at a depth of 400 mm around each transformer and switch and bonded to the main earthing system.

### **EA3.7 Earthing of Buildings**

- a. All hot and cold-water pipes and discharge pipes shall be interconnected by means of 12 x 1,6 mm solid or perforated copper tape and clamped with brass bolts and nuts. Copper tapes shall be fixed to walls by means of brass screws at intervals not exceeding 250mm.
- b. Iron roofs, gutters, down-pipes, etc., shall be interconnected in the same way.
- c. Connections shall be carried out with brass bolts and nuts (not self-tapping screws).
- d. Iron roofs shall be connected at intervals not exceeding 15m with a common earth conductor of bare copper wire. The common earth conductor shall run under the roof over the full length rigidly fixed to the upper purlin.
- e. This earth conductor shall also be connected to the main earth conductor of every distribution board.

- f. When plastic conduit is used, a 2,5mm<sup>2</sup> bare copper conductor shall be installed throughout for earth continuity.
- g. This copper conductor shall be securely fixed to all metal appliances and equipment, including switch boxes, socket outlet boxes, draw boxes, switchboards, luminaires etc.

### **EA3.8 Earthing of LV Systems**

- a. A separate earth connection shall be installed from every sub-distribution board to the earth terminal on the main distribution board. These earth connections shall consist of bare copper conductors, drawn into conduit or piping, together with PVC conductors or cables.
- b. Socket outlets shall be connected with 2,5 mm<sup>2</sup> earth conductor to the earth busbar in the relative distribution board.
- c. The earth terminals of lighting circuits shall be connected to the nearest earth terminals by means of 2,5 mm<sup>2</sup> stranded copper conductors.
- d. A readily accessible earthing terminal shall be provided for the bonding of other services such as a telephone, an audio or a video system, and the like, to a building. Such an earth terminal shall be bonded to the consumers earth terminal by a conductor of at least 6mm<sup>2</sup> copper or equivalent and shall be identified by the earth symbol. Labels shall be fitted to all distribution boards where the readily accessible earthing terminal for the bonding of other services is provided.
- e. The earth terminals on the main distribution board shall be earthed by means of a 70 mm<sup>2</sup> bare copper conductor connected to the earth mat.

### **EA3.9 Earthing Of Installation**

The trench earth shall consist of minimum 70mm<sup>2</sup> bare copper conductor buried in a 600mm trench around each building.

#### **EA3.9.1 Roofs, gutters and down pipes**

All metal parts of roofs, gutters and down pipes shall be bonded and earthed. The roof and gutters shall be connected at 15m intervals or as shown on the drawings to this conductor by means of 50mm<sup>2</sup> down conductors or equivalent as approved by the engineer in 20mm PVC conduit. All bolts and nuts to be galvanised. Self-tapping screws are not acceptable. The earth should be connected to the earth mat.

#### **EA3.9.2 Sub-distribution boards**

A separate earth connection shall be supplied between the earth busbar in each sub-distribution board and the earth busbar in the Main Switchboard. These connections shall consist of a bare or insulated stranded copper conductors installed along the same routes as the supply cables or in the same conduit as the supply conductors. Alternatively, armoured cables with earth continuity conductors included in the armouring may be utilised where specified or approved.

#### **EA3.9.3 Sub-circuits**

The earth conductors of all sub-circuits shall be connected to the earth busbar in the supply board in accordance with SANS 10142.

#### **EA3.9.4 Non-metallic Conduit**

Where non-metallic conduit is specified or allowed, the installation shall comply with the specification for "conduit and conduit accessories".



Stranded copper earth conductors shall be installed in the conduits and fixed securely to all metal appliances and equipment, including metal switch boxes, socket-outlet boxes, draw-boxes, switchboards, luminaires, etc. The securing of earth conductors by means of self-threading screws will not be permitted.

#### EA3.9.5 Flexible Conduit

An earth conductor shall be installed in all non-metal flexible conduit. This earth conductor shall not be installed externally to the flexible conduit but within the conduit with the other conductors. The earth conductor shall be connected to the earth terminals at both ends of the circuit.

#### EA3.9.6 Connection

Under no circumstances shall any connection points, bolts, screws, etc., used for earthing be utilised for any other purpose. It will be the responsibility of the Contractor to supply and fit earth terminals or clamps on equipment and materials that must be earthed where these are not provided.

Unless earth conductors are connected to proper terminals, the end shall be tinned and lugged.

#### EA3.9.7 Lightning Protection

- a. The lightning Protection system shall be designed and installed by a certified specialist contractor.
- b. The lightning protection system of buildings and structures shall include:
  - Bonding of metal roofs and structures
  - Installation of 8mm aluminium Lightning conductor on concrete and non-metallic roof structures
  - Bonding of lightning protection system with earthing system.
- c. The contractor to use approved methods for joints, terminations, and bonding.
  - Lightning conductors shall be fixed to walls and parapets by means of raised galvanised saddles and secured onto the structure.
  - If waterproofing is installed, lightning conductors to be installed above the waterproofing membrane.
  - Care must be taken to prevent damage to waterproofing membranes and any damage or penetration onto waterproofing membranes must be first approved by the waterproofing installers prior to drilling/cutting.
  - All repairs to waterproofing membranes must be done by the specialist waterproofing installers at the contractor's cost.
  - Down conductors to be 50mm copper conductor in PVC conduit to the earth mat of test points as indicated on the drawings.
  - Test points shall be installed 600mm above finished ground level in a suitably approved IP65 box with a removable cover.
  - Test points shall be provided with a bolted connection and labelled for future testing.
  - Down conductor tails from the test point to earth mat/rod shall be of 50mm<sup>2</sup> copper conductor and to be exothermically welded onto the earth mat/rod. No crimps or clamps will be allowed.
  - All drilling of holes onto structures and frames and re-instatement of protective coatings, eg. paint or galvanising shall form part of this contract.
  - All connections to earth rods and conductor joints shall be by means of exothermic welds.
  - Bonding to steel reinforcing shall be by means of approved clamps.

- All connections between different metals shall be by means of suitable bi-metal connections.

## **EA4 LIGHTING FIXTURES**

### **EA4.1 Quality Assurance**

#### **EA4.1.1 Codes and Standards**

The lighting fixtures shall comply fully with the applicable SANS specifications as set out below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS codes will be applicable:

- SANS 475: Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
- SANS 1464: Safety of luminaires Part 22: Luminaires for emergency lighting
- SANS 10114-1: Interior lighting Part 1: Artificial lighting of interiors
- SANS 10114-2: Interior lighting Part 2: Emergency lighting
- SANS 10389-1-3: Exterior lighting Part 1-3
- SANS 61547: Equipment for general lighting purposes – EMC immunity requirements
- SANS 62560: Self-ballasted LED lamps for general lighting services by voltage > 50V - Safety specifications
- SANS 62031: LED modules for general lighting – Safety specifications
- SANS 60598: Luminaires - Part 1: General requirements and tests
- SANS 1662: Self ballasted LED Tubular lamps for general lighting services > 50V - Safety requirements.
- SANS 62612: Self ballasted LED lamps for general lighting services with supply voltages > 50V - Performance requirements.

#### **EA4.1.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- Products must carry the SABS mark or an international certification and approved for use in South Africa.

### **EA4.2 Fluorescent Lighting Fixtures**

#### **A. General**

Furnish and install fluorescent lighting fixtures of the types and manufacturers scheduled on the Drawings. Fixtures shall be furnished with all required accessories and trim as required for a complete installation in the ceiling type shown on the Architectural Drawings.

#### **B. Lamps**

Fluorescent fixtures shall be complete with lamps of the type, colour, wattage, and size indicated on the Lighting Fixture Schedule.

#### **C. Ballasts**

##### **a. General**

Ballasts for use on 230 Volt systems shall be suitable and guaranteed for a voltage range

of 205 Volts to 240 Volts. Ballasts for use on 400 Volt systems shall be suitable and guaranteed for a voltage range of 380 Volts to 420 Volts.

b. **Electronic Ballasts**

- Fluorescent fixtures indicated to be provided with electronic ballasts shall be complete with parallel wired, Class "P" thermal protected, electronic ballasts certified by CE and complying with SANS limits governing EMI and RFI.
- Electronic ballasts shall comply with SANS standards for surge protection. Total harmonic distortion shall not exceed 10%. Ballast case operating temperature shall not exceed 60oC.
- Electronic ballasts shall be capable of starting at temperatures of 0oC or higher.
- Power factor shall not be less than 0.95.

c. **Dimming Ballasts**

Wherever fluorescent fixtures are to be dimmed, the fixture supplier shall coordinate the type of dimming ballast to be used with the dimming equipment supplier to insure compatibility. The fluorescent lighting fixtures shall be provided with circuit interrupting lamp holders as required for the single or double lamp dimming ballasts being used.

d. **Low Temperature Ballasts**

Unless otherwise indicated, where fluorescent lighting fixtures are installed in unheated areas of the building(s) or parking garages, or where installed outdoors, the fixtures shall be provided with the appropriate ballasts with a minimum Sound rating as recommended by the manufacturers.

e. **Low Leakage Ballasts**

Where fluorescent fixtures are installed on isolated power circuits, low leakage ballast suitable for isolated power use shall be provided.

D. **Louvers**

Lighting fixture louvers shall be pre-anodized aluminium semi-specular low-iridescent parabolic louvers. Louver shall be securely fastened with T-hinges and spring-loaded cam latches. The louver should be capable of hinging and latching from either side. All steel parts, excluding fasteners, shall be painted after fabrication. Pre-coat finishes shall not be acceptable.

E. **Guards**

Fluorescent strip fixtures with exposed bare lamps shall be provided with guards as required by safety codes.

F. **Other**

Fluorescent fixtures in continuous rows shall be supplied with all fixture couplings, close nipples and/or other accessories recommended by the manufacturer for continuous row installation.

### **EA4.3 Led Lighting Fixtures**

A. **General**

Furnish and install LED lighting fixtures of the types and manufacturers scheduled on the Drawings. Fixtures shall be furnished with all required accessories and trim for a complete installation in the ceiling type shown on the Architectural Drawings.

B. **Lamps**

LED fixtures shall be complete with lamps of the type, colour, wattage and size indicated on the

Luminaire Schedule, or as specified by the lighting fixture manufacturer. Unless otherwise noted, all lamps shall be Cool white.

**C. Minimum requirements**

- a. The minimum lamp life should be equal or greater than 30 000 hours.
- b. The Colour Rendering Index (CRI) must be 80 or greater.
- c. Power factor must be greater than 0.9.
- d. Test reports from an approved and accredited test laboratory must be submitted when called for.
- e. Alternate fixture manufacturers shall submit computer generated illumination calculations and files (.ies) to the engineer for approval.

**D. Luminaire Markings**

All products shall be marked according to SANS 62031 as follows:

- a. Lamp rating in Watts
- b. Lamp life in hours
- c. Colour Correlated Temperature (CCT) or colour name.
- d. Colour Rendering Index (CRI)
- e. Initial lamp life output
- f. Energy Efficiency Marking /label per SANS codes.

**EA4.4 Area And Floodlighting Fixtures**

- a. Area and Floodlighting fixtures have been selected for specific features, beam characteristics and style. Alternate fixtures will be considered for approval based upon compliance with procedures as described below.
- b. Alternate fixture manufacturers shall submit computer generated illumination calculations and files (.ies) to the engineer for approval.
- c. Floodlighting fixtures shall consist of a cast aluminium housing and housing door assembly. The housing shall contain the optical components and a removable ballast drawer assembly. The unit shall be supported by cast aluminium, adjustable mounting bracket. The unit shall contain no weep or drain holes. A filtered vent hole into the fitter chamber shall be provided. The entire unit shall be classified as a sealed type. It shall bear a IP rating.
- d. Housing shall be a single piece aluminium casting, forming a watertight shell. It shall contain the electrical and optical component compartments.
- e. Housing door shall be cast aluminium and shall hold a tempered heat and impact resistant clear glass lens. It shall be gasketed with high temperature resistant gasket and shall be hinged to the fixture housing with a non-corrosive hinge assembly. It shall be held closed with corrosion resistant captive screws, or stainless steel, spring loaded, quick release latches.
- f. All gasketing material shall be high temperature resistant rubber. All areas that are gasketed shall be of metal to metal or metal to glass interface contact design, to control gasket compression. All gasketing shall provide component compartment sealing, to prevent external atmospheric containment intrusion.
- g. Ballast assembly shall be a self-contained, removable tray assembly of modular design and shall contain all electrical components of the ballast. It shall have a polarized, quick disconnect, mate and lock power input plug. It shall be field interchangeable without requiring the luminaire to be removed. The ballast shall be specifically designed for the lamp type specified and at the voltage specified. Ballast shall be constant wattage autotransformer, high power factor type, with starting current less than operating current.

- h. The socket shall be mogul porcelain enclosed and shall have a spring-loaded, centre contact. It shall be properly positioned to allow correct location of the lamp in the reflector assembly. It shall be specifically designed to withstand the high voltage impulse needed to start the lamp.
- i. Reflector assembly shall be construction of high purity, reflective aluminium material, and shall be designed to provide optimum photometric results in conjunction with the fixtures and the light sources for which they are designed. Fixtures must be available with a minimum of four different reflector assemblies to provide various photometry performances.
- j. Glare shields will be available.
- k. All painted parts shall be coated with powder coat thermoset polyester enamel, formulated to provide no appreciable fading, blistering, or peeling within five (5) years. Colour shall be as specified in the lighting schedule.

#### **EA4.5 Submittals**

- a. Shop drawings submittals shall include, but not be limited to, the following:
- b. Cut sheets on all lighting fixtures with all accessories and details clearly indicated.
- c. Cut sheets and complete technical data on ballasts, lamps, lens, poles, etc.
- d. Photometric performance data.
- e. Computer generated illumination calculations in the latest DIALux format and files (.ies) to the engineer for approval.
- f. Additional information as required.

#### **EA4.6 Installation**

- a. All lighting fixtures shall be furnished complete with mounting accessories to suit the specific service and installation intended. The Electrical Contractor shall verify the required fixture ceiling/trim coordination prior to light fixture orders.
- b. Fixtures shown on the fixture schedule to be recessed shall be complete with plaster frames, mounting yokes, rod hangers, etc., and/or any other accessories required to fit the fixture to the ceiling construction.
- c. However, where ceiling system cannot maintain said support, provide supplemental steel support members connected to the building structure capable of carrying the weight of the fixture plus 100kg at each support without sagging. Provide the necessary supports for hangers located between structural members. Securely fasten the luminaire to the ceiling framing members. In plaster ceilings, provide threaded hanger rods secured to the main ceiling suspension structure and supplementary horizontal steel members as required, and to the luminaire housing, using two nuts at each end of rod.
- d. Connect each ceiling-recessed luminaire into the conduit system by means of flexible cabtyre cable with plug top not more than 3m or less than 1.2m in length routed from an above-ceiling outlet point.
- e. Provide alignment clips on all pendant or ceiling mounted luminaries used in continuous rows.
- f. Chain-suspended lighting fixtures shall be connected to the outlet box mounted directly above the fixture using flexible metallic conduit, and the flexible metallic conduit shall be strapped to the fixture chain.
- g. Fixture supports shall be provided in all outlet boxes from which fixtures are suspended. Fixtures shall not be suspended by means of cover or canopy screws. Canopies shall completely cover the ceiling opening of all ceiling fixtures except lay-in fixtures in T-bar construction, and trimless fixtures.
- h. Where surface mounted lighting fixtures (i.e., exit lights, etc.) are installed on lay-in panels in T-bar ceiling construction, the outlet boxes shall be rigidly supported to the ceiling system using

metal channels spanning perpendicular across the T-bars and securely attached to each side of the outlet box.

- i. Connect each fixture housing to the equipment grounding conductor by means of a crimped spade-type terminal connector secured to the housing with a self-tapping screw.
- j. All fixtures shall be clean at the time of acceptance of the Work and shall be properly aimed or adjustable as required. No extra will be permitted for cleaning, aiming or adjustable fixtures to meet the requirements of the Engineer at the time of acceptance of the Work.
- k. All lamps used during construction and prior to final inspection, shall be replaced prior to final acceptance of the building by the Owner.
- l. The locations indicated for outlet boxes of lighting fixtures are diagrammatic. Outlets shall be located as required to coincide with suspension hangers where they occur and with structural an architectural element of the building and shall be located in accordance with the Architectural Reflected Ceiling Plan (RCP).

#### **EA4.7 Mounting And Positioning Of Luminaires**

- a. The Contractor is to note that in the case of board and acoustic tile ceilings, i.e. as opposed to concrete slabs, close co-operation with the building contractor is necessary to ensure that as far as possible the luminaires are symmetrically positioned with regard to the ceiling pattern.
- b. The layout of the luminaires as indicated on the drawings must be adhered to as far as possible and must be confirmed with the Engineer or representative.
- c. Fluorescent luminaires installed against concrete ceilings shall be screwed to the outlet boxes and in addition 2 x 6mm expansion or other approved type fixing bolts are to be provided. The bolts are to be  $\frac{3}{4}$  of the length of the luminaires apart.
- d. Fluorescent luminaires to be mounted on board ceilings shall be secured by means of two 40mm x No. 10 round head screws and washers. The luminaires shall also be bonded to the circuit conduit by means of locknuts and brass bushes. The fixing screws are to be placed  $\frac{3}{4}$  of the length of the fitting apart.
- e. Earth conductors must be drawn in with the circuit wiring and connected to the earthing terminal of all fluorescent luminaires as well as other luminaires exposed to the weather in accordance with the "Wiring Code".
- f. Luminaires are to be screwed directly to outlet boxes in concrete slabs. Against board ceilings the luminaires shall be secured to the bracing or joists by means of two 40mm x No. 8 round head screws.

#### **EA4.8 Luminaire Identification**

- a. Lighting outlets are numbered on the drawings.
- b. The numbering of the outlets defines the circuitry and control required. Each luminaire shall be furnished with the wattage and colour as specified or as implied by the catalogue number of the luminaires specified.
- c. The luminaire shall bear the SANS 60598-2-3 and SANS 60598-2-5 safety mark or equivalent International rating. The luminaire shall have a Ta rating not less than  $= 40^{\circ}\text{C}$ . The luminaire shall be manufactured by an ISO 9002 accredited company. The luminaires company shall be a ISO Marked Bearing Company or International Equivalent.

#### **EA4.9 General**

The electrical subcontractor shall only commence with the installation of light fittings after the paintwork in the vicinity of the fitting is complete and dry. Care shall be taken to ensure that ceiling

boards and paintwork is not damaged during the installation of light fittings. The type of light fittings to be used are indicated and specified on both the relevant drawings as well as in the lighting schedule.

A. Positions of light fittings

The mounting positions of light fittings are indicated on the relevant drawings and shall be verified on site.

B. Mounting heights of light switches

Light switches shall be installed 1,4 metres above finished floor level unless specified to the contrary.

C. Mounting of light fittings

- a. Surface mounted fittings shall be screwed to the ceiling by means of at least two 4 mm diameter electroplated self-tapping screws.
- b. On concrete, plastered and brick surfaces good quality plastic expansion plugs shall be used and on suspended and soft ceilings a solid timber backing strip of at least 40 x 40 mm timber shall be supplied and installed between supports and the screws fixed to these backing strips.
- c. Surface mounted fluorescent fittings will be rigidly mounted to ensure close contact with the ceiling over the entire length of the fitting.
- d. On concrete slabs the fittings shall be mounted by means of two screws into the ceiling conduit box as well as two round headed 4 mm x 30 mm electroplated self-tapping screws and plastic expansion plugs, one at either end.
- e. On suspended ceilings the fittings shall be similarly mounted but timber backing strips of at least 40 x 40 x 450 mm shall be placed in position on top of the ceiling board and the end screws secured to these strips to spread the load.

#### **EA4.10 Specification For The Installation Of Lighting**

This is the general Specification for the Installation of Lighting at the pump stations. All lighting installations shall comply with the Occupational Health and Safety Act (85 of 1993) and the SABS Wiring Codes of practice 01042. All lighting offered shall be of the latest energy efficient lighting and control. All lighting shall be off the Eskom approved energy saving LED type and shall match or exceed the existing lux levels.

The installation shall be done in the manner outlined below in the following areas.

**Panel Room, Outside, Dry and Wet Well Lights**

Type of light Fixture

Five Foot (5ft) double dust and hose proof light fittings/250MV.

Method of Mounting

All light fittings shall be mounted with 8mm x 40mm stainless steel Double Wedged anchor Bolts.

Method of Termination:

Each light fitting shall have a 500mm, two core plus earth cable. Tail piece that is to be terminated in a four way round junction. Box (preferred CCG No1), having a rating of no less than Ip65. The strip connectors shall be rated at 30amps for ease of connection and disconnection.

Electrical Circuit

The lighting circuit in each location shall have its own circuit breaker and must be labelled.

**Light Switch**

Each location shall have its own weatherproof light switch in its own enclosure and be labelled. This should be mounted at the main door entrance of the panel room or as instructed by the Engineer.

**Mounting Height**

The light fittings shall be mounted at a height that is maintenance friendly. If a ladder is to be used it shall be of a maximum of a 5ft ladder. Lights in sumps must be mounted out of the flood zones.

**General Installation of Conduits**

The use of PVC conduit is only permitted if it is installed in such a manner that it is Not exposed to direct sunlight. Hospital or spacer bar saddles shall be used to fix the conduit onto the wall. Bosal pipe must be used for outside installations.

**Outside Lighting**

These lights shall be controlled via a Photocell and Contactor with bypass. They shall be of the weatherproof type.

**Type of Fitting and Quantity Required:**

Name of Pump Station	Out Side	Panel Room	Dry Well/ Old Pump station	Wet Well
	50W LED Flood Lights	5Ft Double Dust and Hose Proof.	5Ft Double Dust and Hose Proof.	50W LED Flood Lights

**EA5 CIRCUIT WIRING AND OUTLET POINTS****EA5.1 Quality Assurance****EA5.1.1 Codes and Standards**

The conduit and conduit accessories shall comply fully with the applicable SANS specifications as set out below and the conduit shall bear the mark of approval of the South African Bureau of Standards.

- The latest issue of SANS 60614 and SANS 61035, parts 1 and 2: Metallic conduit and accessories
- The latest issue of SANS 950: Non-metallic conduit and accessories
- The latest issue of SANS 1507: Electric cables with extruded solid dielectric insulation for fixed installations.

**EA5.2 Conductors****A. General**

- All wiring shall, unless expressly stated otherwise in the detail specification, comprise of PVC insulated, stranded copper conductors and bare stranded copper or green PVC insulated, stranded earth continuity conductors. The conductors shall comprise of high conductivity annealed stranded copper conductors and shall be insulated with general purpose PVC, of the 600/1000 grade. All conductors used for the wiring of the electrical installation shall comply with SANS 1507.
- Conductors shall be from new stocks and shall be delivered to site with unbroken seals.

**B. The following PVC insulated unarmoured cables with a bare earth conductor are considered:**

- PVC insulated flat multicore cable with a bare earth conductor.



- b. PVC insulated round multicore cable with a bare earth conductor and with metal stiffening.

C. Wiring Terminals

- a. Terminal bodies and screws shall be constructed from non-corrosive metal, enclosed in fire resistant, moulded plastic insulating bodies. No part of the terminal body or fastening screws shall project beyond the insulating material which shall afford suitable protection against accidental contact by personnel and against short circuits or tracking.
- b. The terminal block and its associated mounting rail shall be constructed in such a manner as to ensure a firm and positive fastening of the terminal block to the rail. Terminal blocks shall be held in position by means of standard end clamps. It shall furthermore be possible to extend the terminal block by adding additional terminal blocks within the terminal sequence without having to disconnect or dismantle the terminal strip.
- c. It shall be possible to intermix terminals of various sizes, for different conductor sizes, whilst utilising the same mounting rail. Where smaller terminal blocks occur adjacent to larger terminal blocks, suitable shielding barriers shall be inserted to conceal the terminals that might otherwise be exposed.
- d. The terminal bodies and clamping screws shall be so constructed as to ensure that conductors are not needed or severed when the clamping screws are tightened. Screws shall not come into direct contact with the conductors. Each terminal block shall have provision for clip-in numbering or labelling strips to be installed, together with protective, clear caps over the sheets.

**EA5.3 Installation**

A. General

The electrical subcontractor shall ensure that the wiring of the electrical installation for the building or other structure is carried out in accordance with SANS 10142.

B. Wireways

All unarmoured conductors shall be installed in conduits, trunking or power skirting and such conductors shall under no circumstances be exposed.

C. Circuits

The circuits for the complete electrical installation are indicated on the relevant drawings. The following are the maximum number of points normally connected to each type of circuit unless otherwise indicated on the drawings:

- a. Light points per circuit = 8
- b. Socket outlets per circuit = 4
- c. Air conditioner points per circuit = 2
- d. Stoves, etc = 1

Conductors supplying circuits which are fed from different switchboards shall not be installed in the same wireway. The wiring of one circuit only will be allowed in a 20 mm diameter conduit, with the exception of the wiring from switch boards to fabricated sheet metal boxes located close to switchboards, in which case more than one circuit will be allowed. For larger conduit sizes the requirements of SANS 10142 shall be met.

D. Looping and joints

A loop-in wiring system where conductors are looped from outlet to outlet shall be employed. Joints in conductors shall be avoided as far as possible but where it becomes unavoidable,

joints will be accepted in cable channels only and not in conduits. Joints shall be soldered or shall alternatively consist of approved ferruling properly covered with the correct size heat-shrink sleeves. The use of PVC insulation tape is not acceptable.

E. Grouping of conductors

In cases where the conductors of more than one circuit are installed in the same wireway, the conductors of each separate circuit, including the circuit earth continuity conductor, shall be grouped at intervals of at least one (1) metre using plastic cable ties. The conductors of different circuits shall however remain separate in order to ensure that any given circuit may be withdrawn from the wireway. Conductors entering distribution boards or control boards shall be grouped and bound by means of plastic cable bands. The use of PVC insulation tape for grouping conductors will not be accepted.

F. Pulling-through of conductors

The electrical subcontractor shall take utmost care whilst pulling conductors through conduit to ensure that the conductors are not kinked, twisted or strained in any manner. Care shall furthermore be taken to ensure that conductors do not come into contact with materials or surfaces that may damage or otherwise adversely affect the insulation and durability of the conductor.

G. Conductor colours

The colours of conductor PVC insulation shall comply with SANS 10142. The colours of conductors for sub-circuits shall as far as possible, correspond with the colour of the supply phase. The colours of conductors for the wiring of two-way and intermediate switches shall preferably differ from the colour of phase conductors.

H. Earth continuity conductors

- a. Bare copper earth continuity conductors or green PVC insulated stranded copper earth continuity conductors, as specified in the detail specification, shall be used throughout the installation.
- b. When earth continuity conductors are looped between earth terminals of equipment, the looped conductor ends shall be twisted together and then ferruled or soldered to ensure that a positive earth continuity is maintained when the conductors are removed from any earth terminal.
- c. Where bare copper earth wires are specified for circuits installed in power skirting and floor ducting, the electrical subcontractor shall provide a suitable length of PVC sleeving over the bare earth conductor where it passes behind or is connected to power outlets to ensure that such an earth conductor does not come into contact with any live parts.

I. Wiring inside vertical wireways

Conductors installed in vertical wireways shall be secured at intervals not exceeding 5m to support the weight of the conductors. Approved clamps shall be supplied and installed in suitable draw-boxes for this purpose.

J. Conductor sizes

The conductor size for each circuit type is specified in the detail specification. In the event that a conductor size is not specified in the detail specification, the following minimum conductor sizes shall be used:

Circuit	Minimum Conductor (Size)	
	Phase (mm <sup>2</sup> )	Earth (mm <sup>2</sup> )
Lighting	1,5	2,5
Socket outlet	2,5	2,5
Stove	6.0	6.0
Air-conditioner	4.0	2.5
Geyser	4.0	2.5

K. Single pole switches

Single pole switches shall be connected to the phase conductor and shall not be connected to the neutral conductor.

L. Three phase outlets

- a. With the exception of three phase outlets, wirings to circuits connected to different phases shall not normally be present at lighting, switch or socket outlet boxes. Where this is unavoidable, barriers shall be provided between terminals or connections of the various phases and the box shall be suitably labelled internally and externally to indicate the presence of three phase voltages.
- b. A separate neutral conductor shall be installed together with each three-phase circuit to outlets intended for equipment connection by means of isolators or sockets, irrespective of whether the particular equipment normally requires a neutral or not.

M. Connections

- a. The insulation of conductors shall only be removed over the portion of the conductors that enter the terminals of switches, socket-outlets, or other equipment. When more than one conductor enters a terminal, the strands shall be securely twisted together.
- b. Under no circumstances shall any of the strands be removed to enable easier insertion of the conductors into terminals.
- c. No more than two conductors shall be permitted to be fastened to any one terminal. The electrical contractor shall take care to ensure that the copper strands are not kicked during the removal of the insulation. PVC insulated conductors shall not be used for the direct connection to equipment where the temperature exceeds 75°C, such as stoves, geysers, electric water heaters and high-power LED lamps. Silicon coated or other approved conductors shall be used in such cases.

N. Terminals

Terminals shall be sized and current rated to match the conductors that are connected to them.

#### EA5.4 Power Outlets

A. General

The electrical contractors shall only commence with the installation of power outlets in the conduit outlets allowed therefore of the plasterer and painter have completed their work in the vicinity of the outlet.

B. Socket outlets with switches

- a. All socket outlets with switches shall be of the standard 16A 3-pin pattern, white in colour. Emergency socket outlets shall be red, with the flattened earth pin on top. UPS outlets shall be blue, with the flattened earth pin on the right.

- b. Units for flush mounting shall be suitable for 100 x 100 x 50 mm deep flush wall box. Surface mounted patterns shall be housed in heavy pressed steel boxes. Shutters shall be provided. All socket outlets with switches shall be continuously rated at 16A and shall be suitable for operation on a 250V, 50 Hz, a.c. system.
- c. All socket outlets with switches shall fully comply with SANS 164 as amended. Covers shall have bevelled edges which overlap the box.

C. Isolators

- a. Moulded case isolators shall be of the double pole ON-LOAD type.
- b. Toggles shall be interlocked with the covers. All isolators shall comply with SANS 60947. To distinguish the switches from circuit breakers the operating handles of isolators shall have a distinctive colour and where called for in the "particular specification" the switch shall be clearly and indelibly labelled "ISOLATOR".

## EA5.5 Installation

A. General

Socket outlets and power outlets shall be installed in the positions as indicated on the drawings.

B. Socket outlets

Unless otherwise specified socket outlets shall be installed at the following heights above finished floor level, measured to the underside of the outlet:

Outlet Point	Location	Height (from finished floor level to underside of outlet)
Socket Outlet	General applications	300mm
Socket Outlet	Kitchens	1200mm
Geyser isolator	Within 1m of geyser	500mm
Heaters, fans & air conditioners	Within 1m of unit	1500mm

C. Connections to geysers

Each geyser shall be connected to a separate circuit with a separate earth conductor. The conduit from the distribution board shall terminate in a 100 x 100 x 50 mm outlet box within 1 metre of the geyser. A suitably rated double pole isolator shall be installed in the outlet box. A flexible conduit shall be installed between the isolator and the geyser.

D. Connections to heaters, fans and air conditioners

- a. A suitably rated double pole isolator shall be supplied and installed within 1 metre of heaters, fans, and air conditioners. Where the equipment is out of reach the isolator shall be installed 1,5 metres above floor level. Flexible cords of sufficient rating may be used for the final connection to the equipment.
- b. Where control units are to be installed the units shall be installed 1,5 metres above floor level.

## EA5.6 Light Switches

A. Flush mounted switches

- a. Flush mounted switches shall comply with SANS 60947 and shall bear the SABS mark. All flush mounted switches shall be suitable for mounting in 100 x 50 x 50 mm galvanised steel wall boxes unless otherwise specified in the detail specification.

- b. The switch mechanism shall be of the tumbler operated micro-gap type with silent operation and shall be rated for 16 A at 250 V and 50 Hz.
  - c. Switches shall have protected terminals for safe wiring. Multi-lever switches shall be constructed so as to enable individual defective switches to be removed and replaced without having to remove the remaining switches.
  - d. The mounting holes provided on the yoke strap shall be slotted to allow for easy alignment. A brass earthing terminal shall furthermore be provided on the yoke to ensure the positive earthing of the switch assembly.
- B. Switches with pilot light indication
- a. Flush mounted switches with pilot light indication shall comply with the relevant SANS specification and shall bear the SABS mark.
  - b. Switches with pilot light indication shall be suitable for mounting in 100 x 50 x 50 mm galvanised steel wall boxes. The switch shall be rated at 16 A at 250 V and 50 Hz. A red neon indication lamp shall form an integral part of the switch level and shall light-up when the switch is in the on position.
- C. Cover plates for switches
- a. Cover plates for flush mounted switches shall have levelled edges which overlap the wall box in order to conceal all wall imperfections and shall conform to SANS 60947.
  - b. Cover plates shall be finished in ivory coloured baked enamel and shall bear the identical manufacturing batch number.
- D. Surface mounted switches
- a. Surface mounted switches shall comply with SANS 60947 and shall bear the SABS mark. Surface mounted switches shall consist of single or multiple switches, not exceeding four, and shall be mounted in a pressed steel box of heavy-duty construction.
  - b. The switch mechanism shall be of the tumbler operated micro-gap type with silent operation and shall be rated for 16 A at 250 V and 50 Hz.
  - c. A brass earthing terminal shall furthermore be provided on the switch construction to ensure the positive earthing of the switch assembly and enclosure.
  - d. The covers of surface mounted switches shall have toggle protectors.
- E. Watertight Switches
- Watertight switches shall consist of 10A switches on porcelain bases in cast iron or aluminium alloy housing. Contacts must be of heavy-duty brass construction and a quick acting spring mechanism shall be fitted. A rigid operating knob shall be clearly marked to indicate the "ON" and "OFF" positions. Conduit entry shall be provided through a tapped hole. The complete unit shall be watertight.

#### **EA5.7 Telephone and Data Outlets**

- a. Telephone and data outlets in walls shall comprise of 100 mm x 100 mm x 50 mm deep wall boxes which shall be flush mounted in the wall, in the position shown on the relevant drawing, with the underside 300 mm above the finished floor level. The wall box shall be fitted with a blank cover plate. All outlet boxes shall align up neatly with adjacent socket outlet wall boxes. Telephone and data outlets in floors fitted with floor ducting shall be of the same type as the floor outlets for power socket outlets and shall normally be provided in the same outlet box.
- b. Telephone and data outlets in power skirting shall be provided in the positions shown on the relevant drawing and the electrical subcontractor need only provide a separate short length cover plate at these positions. The cover plate for the fixing of the telephone and data outlet

shall not exceed 250 mm in length and shall be secured in such a manner that adjacent cover plate sections may be removed without disturbing the telephone outlet.

## **EA6 DUCTS AND POWER SKIRTING**

### **EA6.1 Quality Assurance**

#### **EA6.1.1 Codes and Standards**

The ducts and power skirting shall comply fully with the applicable SANS specifications as set out below and the conduit shall bear the mark of approval of the South African Bureau of Standards.

- a. SANS 61084: Cable trunking and ducting systems for electrical installations

#### **EA6.1.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa

#### **EA6.1.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

### **EA6.2 Power Trunking**

- a. The Contractor shall be responsible for the supply and installation of all power trunking complete with corner pieces, end pieces, junction pieces, supply conduits, cover plates and power outlets as specified and indicated on the drawings.
- b. The power trunking must comply with SANS 61084. The Contractor must ensure that the power trunking is installed to satisfaction of the Employer's representative before commencing with the wiring of the power trunking.

### **EA6.3 Underfloor Ducting**

This section covers two or three compartment underfloor ducting in buildings.

- a. The ducting and associated accessories shall be manufactured from 2 mm thick sheet steel. The sheet steel shall either be galvanised prior to the manufacturing of the ducting or shall be epoxy powder coated after manufacture. The three-compartment ducting shall be subdivided into three approximately equal compartments, of which the centre compartment shall be used for electrical power distribution with the outer two compartments for other services.
- b. Outlets shall be provided on a modular basis in the ducting for the installation of pedestal or recessed outlets. The openings shall have removable flush cover plates and shall have tapped holes for the installation of the pedestal or recessed outlets.
- c. The underfloor ducting shall be complete with flush cross-over, T-junction and right-angle bend draw boxes. The junction boxes shall be complete with cross-over of services and removal cover plates secured by means of countersunk screws.

- d. Pedestals suitable for two or three services as specified shall be manufactured from die-cast aluminium or pressed steel. The pedestals shall be epoxy coated of an approved colour after the manufacturing hereof.
- e. The underfloor ducting with accessories shall be installed strictly in accordance with the manufacturer's instructions. The ducting shall be fixed to the floor by approved means.
- f. Up-bends shall be supplied and installed wherever the ducting is terminated at distribution boards, telephone distribution boards or behind power skirting.
- g. The power circuit wiring shall be installed in the centre compartment of the ducting. Sufficient slack shall be left in the form of a loop at each outlet in the ducting in the area to be served by the ducting. Galvanised draw wires shall be installed in the other compartments to enable cables to be drawn in by others. The entire installation shall be effectively earthed and bonded together.

#### **EA6.4 Power Skirting**

This section covers the supply and installing of two or three compartment power skirting.

- a. The power skirting and covers shall be manufactured from 1 mm thick sheet steel or aluminium and shall be manufactured in modular lengths. The length of the skirting shall not exceed 2,5 metres and, unless otherwise specified in the detail specification, the covers shall be supplied in 1 metre lengths.
- b. The covers shall either snap on or shall be fixed by means of toggle or swivel nuts. Each modular cover shall be punched and prepared for the installation of a standard three pin socket outlet. The punched holes shall be blanked off with easily removable blanking plates, painted the same colour as the power skirting. Suitable brackets shall be supplied for the fixing of the socket outlet to the channel.
- c. All internal and external bends and off sets shall be factory made.
- d. The power skirting and cover shall be epoxy powder coated of an approved colour after the manufacturing thereof.
- e. Conduits for the circuit wiring to the power skirting shall be installed in the floor-slabs and chased into the walls to terminate in flush conduit boxes behind the power skirting at the heights of the compartments for the telephone, power and other service compartments.
- f. The wiring shall pass through large diameter holes, suitably bushed, cut in the rear of the power skirting.
- g. Where power skirting is interrupted by doorways bridging conduits shall be installed for each of the service compartments.

#### **EA6.5 Wireway Trunking**

##### **A. General**

This section covers the supply and installation of wireway trunking and accessories in buildings.

##### **B. Materials**

The covers of the wireway trunking shall be secured to the framework by at least four points per section. Covers shall be so designed that they can be easily removed after installation of the trunking. Sections of the trunking which pass through walls and floors shall have separate covers. Fire barriers of non-flammable, non-conducting material shall form an integral part of each section. The fire barriers shall be so placed as to prevent the spreading of fire from one floor to another.

C. Installation

- a. Trunking shall be of the size and type as specified in the detail specification. The electrical contractor shall ensure that the trunking is installed in accordance with the routes indicated on the relevant drawings.
- b. However, should the electrical contractor discover that the indicated route is not practically possible, or for some other reason the route clashes with other services, he shall immediately contact the engineer for clarification in this regard.

D. Ceiling space

- a. Trunking for use as wireways shall be installed as specified on the drawings. When installed in open ceiling spaces, trunking shall be mounted as close as is physically possible to immediately below the apex of the roof to allow maximum working space. The trunking shall be installed along the full length of the open ceiling space. Individual conduits shall be extended from the trunking to switch and socket outlet boxes, light points, distribution boards, etc.
- b. The trunking shall be installed in one straight length and all joints shall be both electrically and mechanically continuous. The trunking shall only be installed where there is a minimum clearance of 750 mm as measured between the top of the final trunking installation and the underside of the roof sheeting. The trunking shall be securely fixed to every roof truss or member by means of round headed screws or approved truss clamps.
- c. Both incoming and outgoing conduits shall be bonded to clean surfaces, both internally and externally, by means of two locknuts and a female brass bush. A solid brass bushnut installed from inside the trunking may also be used. Conduits which are extended from the trunking to outlets and power points shall be installed along roof members. Suitable timber or other supports shall be provided for free standing conduits extended from the trunking.

E. Suspending or fixing trunking against walls

- a. The electrical contractor shall provide all the necessary hangers, supports, brackets and fixing hardware for the securing of the trunking installation.
- b. Trunking up to and including 76 mm x 76 mm shall be supported at regular maximum spacings of 600 mm and larger channels at regular maximum spacings of 1 m. Trunking runs shall be carefully planned to prevent clashes with other services and to ensure that all covers can be easily removed after completion of the installation. Purpose made clamps and hangers shall be provided as required. Where however it is not possible to support the trunking at the specified spacings, such trunking sections shall be supported in a sound manner and to the approval of the engineer.

F. Cast in concrete.

- a. Where trunking is to be cast into concrete, the insert type of trunking shall be used. Spacer blocks shall be used where required to prevent the trunking from being deformed during the casting of the concrete.
- b. The trunking shall be filled with polystyrene or other suitable fillers, prior to casting, to prevent the ingress of concrete. The trunking shall furthermore be securely fixed in position to the shuttering.

G. Conduit connections

Conduit connections shall be bonded to clean surfaces, both internally and externally, by means of either two locknuts and a female brass bush or by means of a solid brass nut inserted from the inside of the trunking. Conduit connections may be made by means of a conduit box if the trunking is wide enough to allow a hole to be punched through the back or side thereof. All holes through which conductors pass shall be fitted with bushes, grommets or shall be aligned with



PVC strip grommet.

H. Joints and bends

- a. Two adjoining lengths of trunking shall be aligned and shall be securely joined by means of fishplates fixed by means of mushroom bolts, washers, and nuts. Alternatively, connection pieces that are pop-riveted to both adjoining sections may be used. All adjoining lengths of trunking shall be rectangular and shall burr tightly. Special care shall be taken to ensure that the covers fit tightly across the joints.
- b. Where the trunking passes through an expansion joint in the structure, suitable expansion joints shall be provided in the trunking by means of fishplates which are to be pop-riveted or screwed to the trunking on one side of the expansion joint, without obstruction in the trunking on the opposite side of the expansion joint.
- c. Bends and T-joints shall be constructed to ensure compliance with the minimum allowable bending radii as specified in SANS 10142, in the case of PVC insulated cables and conductors.
- d. All burrs and sharp edges shall be removed from the cut edges of the trunking and the inside edges shall be lined with a suitable rubberised or plastic compound to prevent laceration of the conductor insulation during installation.

I. Circuits

- a. The conductors for each individual circuit, including the earth continuity conductor for that circuit, shall be grouped together at regular spacings not exceeding 500 mm by means of PVC cable ties or straps.
- b. Each circuit to be installed inside the trunking shall be individually laid to avoid unnecessary tangling of the grouped conductor. The utilized cross-sectional area of the trunking shall not normally exceed 50% of the total cross section of the specified trunking.

J. Earthing

A separate earth continuity conductor of size as specified in the detail specification shall be installed from the main earth bar or terminal to the trunking where it shall be terminated to ensure a proper earthing of the trunking. The earth conductor shall be equipped with a crimped or soldered lug and shall be bolted to the wall of the trunking by means of a 6 mm Ø brass bolt, washers, and nut.

K. Cover plates

Cover plates shall be installed over the full length of the installed trunking. Flush mounted trunking shall be provided with overlapping metal cover plates with plastic edge trim to cover irregularities in the wall recess. Where required and when specified, in the detail specification, cover plates shall be attached to the trunking by means of screws at suitable intervals to prevent warping.

L. Vermin-proofing

After installation all trunking shall be suitably vermin proofed. Any holes present in the trunking shall be sealed by means of screwed metal plugs or else with metal strips which are tube-bolted or pop-riveted to the trunking. No timber or other temporary form of plug shall be accepted. Cover plates shall be installed over the full length of the trunking.

## EA7 LV CABLES

Refer to EA12.

## **EA8 SWITCHBOARDS AND DISTRIBUTION BOARDS**

### **EA8.1 Quality Assurance**

#### **EA8.1.1 Codes and Standards**

Switchboards and distribution boards supplied and installed shall comply with the following Acts and regulations:

- a. The latest issue of SANS 556: "Low-voltage switchgear Part 1: Circuit-breakers
- b. The latest issue of SANS 1765: "Low-voltage switchgear and control gear assemblies (distribution boards) with a rated short-circuit withstand strength up to and including 10 kA".
- c. The latest issue of SANS 60439: 1-5: "Low-voltage switchgear and control gear assemblies",
- d. The latest issue of SANS 60947: 1-8: "Low-voltage switchgear and control gear",
- e. The latest issue of SANS 1973: "Low-voltage switchgear and control gear ASSEMBLIES Part 1-8",
- f. The latest issue of NRS 003: "Metal-clad switchgear - For rated a.c. voltages above 1 kV and up to and including 24 kV Part 2: Standardized panels
- g. Codes and standards as per Design Criteria.

#### **EA8.1.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

#### **EA8.1.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

### **EA8.2 Distribution Switchboards**

Distribution switchboards shall have construction with group mounted circuit protective devices and include the following:

- Switchboard
- Circuit Protective Devices

#### **A. General**

- a. Switchboards shall consist of the required number of vertical sections bolted together to form one metal enclosed rigid switchboard for circuit protective devices and busbar work. Front and side plates shall be screw removable.
- b. Switchboards shall be designed as freestanding switchgear with front only access or otherwise noted on the drawings. This switchgear shall be designed with group mounted devices and isolated busbars, expandable for future sections by the addition of simple splice plates on the horizontal busbar. An air space of at least 50mm or a minimum 3mm thickness insulating barrier shall be provided between end of bus bar and end panel. Switchboard shall be front and rear aligned to a common depth. Switchboard shall be of indoor switchboard construction.

- c. The switchboard shall include all protective devices and equipment as shown with necessary interconnections, instrumentation, and control wiring. Small wiring, necessary fuse blocks, and terminal blocks within the switchboard shall be furnished. All groups of control wires leaving and switchboard shall be furnished with terminal blocks with suitable numbering strips. All wiring within switchboard enclosure shall utilize insulated copper conductors.
- B. Enclosure Construction
  - a. Switchboard framework shall be fabricated on a preformed steel base, or base assembly, consisting of a minimum of 1.6mm corrosion resistant mild steel and commercial channel welded or bolted together to rigidly support the entire shipping unit for moving on rollers and floor mounting. The framework shall be formed of gauge mild steel, rigidly welded and bolted together to support all cover plates, busbars, and component devices during shipment and installation.
  - b. Each switchboard section shall have an open bottom and individually removable top plates for installation and termination of cables and conduit. Top and bottom conduit areas shall be clearly shown and dimensioned on the shop drawings. All closure plates shall be formed up on all sides, screw removable and small enough for easy handling by one man.
  - c. All steel surfaces shall be chemically cleaned and treated to provide a bond between paint and metal surfaces to prevent moisture entrance and rust formation under the paint film. The paint finish shall be two (2) coats of gray enamel over a rust-inhibiting phosphate primer.
  - d. Baked enamel finish is acceptable if applied to properly prepared surface.
- C. Assembly, Wiring and Controls
  - a. The switchboard shall be completely assembled, wired, adjusted and tested at the factory. After assembly, the complete switchboard will be tested for operation under simulated service conditions to assure the accuracy of the wiring and the functioning of all equipment. The main circuits shall be given a dielectric test of 2200 Volts for one minute between live parts and ground and between opposite polarities.
  - b. The wiring and controls shall be given a dielectric test of 1500 Volts for one minute between live parts and ground. A certified test report shall be available to the engineer for approval.
- D. Busbars
  - a. The switchboard busbars shall be 98% conductivity copper with bolted joint connections and of sufficient cross-sectional area to continuously conduct rated full load current with a maximum temperature rise of 65°C above an ambient temperature of 40°C. The switchboard shall have a full size, full length isolated neutral bus and a full-length copper earth bar.
  - b. The bus bars shall be rigidly braced to comply with the integrated equipment rating of the switchgear. The minimum interrupting current rating shall not be less than 65,000 AMPS symmetrical. The main horizontal bus bars between sections shall be located on the back of the switchboard to permit maximum available conduit area. Busbar supports shall be non-carbonizing, non-tracking insulators arranged to provide short circuit bracing as specified. All bolted joint hardware shall be equipped with lock washers and torqued to the Manufacturer's recommended settings. Bolted joint connection surfaces for copper busbars shall be silver plated.
  - c. Torque settings shall be provided for use during installation.
  - d. Busbars shall be arranged A-B-C, left-to-right, top-to-bottom, and front-to-rear, throughout. A ground busbar shall be secured to each vertical section structure and extend the entire length of the switchboard.

- e. Where "space" is shown on one-line drawings, space shall be provided for installation of future switches, sized as shown.
- f. Distribution feeder conductors shall be terminated on the "load side" of switchboard devices with hydraulically applied, high conductivity, compression lugs approved for the purpose. Where conductor connections are required to the main bus, they shall be made with copper bodied compression connectors.

E. Integrated Equipment Rating

Each switchboard, as a complete unit, shall be given a single integrated equipment rating by the manufacturer. The integrated equipment short-circuit rating shall certify that all equipment is capable of withstanding the stresses of a fault equal to that shown on the drawings, in RMS symmetrical amperes. Such ratings shall have been established by actual tests by the manufacturer, in equipment of similar construction as that of the project switchboard. This test data shall be available and furnished, if requested, with or before the submittal of shop drawings.

F. Electronic Power Monitoring System

- a. Each switchboard shall be provided with an electronic circuit monitoring system.
- b. The Circuit Monitor shall accept inputs from industry standard instrument transformers. The current and voltage signals shall be digitally sampled at a rate high enough to provide accurate RMS sensing and valid data for wave form analysis beyond the 30th harmonic based on a fundamental frequency of the 50 Hz. All set-up parameters required by the Circuit Monitor shall be stored in non-volatile memory (no backup battery) and retained in event of a control power interruption. The instantaneous values and the time and date for the highest peak of all demand readings shall also be maintained in non-volatile memory.
- c. The Circuit Monitor shall have capability to perform the following readings:
  - Current per Phase RMS ( $\pm 1\%$ ).
  - Three Phase Average RMS Current ( $\pm 1\%$ ).
  - Apparent RMS Current ( $\pm 1\%$ ).
  - Phase-to-Phase and Phase-to-Neutral Voltage ( $\pm 1\%$ ).
  - Three Phase and per Phase Power Factor ( $\pm 2\%$ ).
  - Three Phase Real and Reactive Power ( $\pm 2\%$ ).
  - Three Phase KVA ( $\pm 2\%$ ).
  - Frequency ( $\pm 0.5\%$ ).
  - Temperature ( $\pm 2-1/2^{\circ}\text{C}$ ).
  - Average Demand Current per Phase ( $\pm 2\%$ ).
  - Peak Demand Current per Phase ( $\pm 2\%$ ).
  - Average Real Power Demand ( $\pm 2\%$ ).
  - Predicted Real Power Demand ( $\pm 2\%$ ).
  - Peak Real Power Demand ( $\pm 2\%$ ).
  - Accumulated energy ( $\pm 2\%$ ).
  - Accumulated reactive energy ( $\pm 2\%$ ).
- d. The Circuit Monitor waveform capture capability shall, upon user command, capture and store, in non-volatile memory, three phase voltage and current samples consisting of 256 data points each. The data points shall represent at least three cycles of each current or voltage waveform. The samples shall be evenly gathered from each voltage and current phase input such that the original power signals with proper magnitude and phase relationships may be reconstructed. It shall be possible to recreate the original power signal from the stored data with sufficient accuracy such that steady-state power harmonic analysis will provide valid information on harmonic content up to the 30th harmonic.

- e. All data and calculated values stored in the Circuit Monitor shall be accessible to external devices by means of a built-in RS485/RS422 serial communications port. It shall be possible to connect from one communication port to another such that up to 16 Circuit Monitors may be connected to form a continuous string extending up to 1000m. These strings shall form individual data transfer networks that comply with the RS485 multi-drop communications standards.
- f. Communication rates for each circuit monitor shall be adjustable up to 19,200 Baud.
- g. Circuit Monitors shall be installed by the switchboard manufacturer. All control power, CT, PT, and communications components shall be factory wired and harnessed within the switchboard line-up. The Circuit Monitor shall be mounted on the front panel of the main switchboard incoming line compartment.

### **EA8.3 Submittals**

Shop drawing submittals shall include, but not be limited to, the following:

- a. Switchboard shop drawings with all busbar and switch ratings, capacities, characteristics, features and associated accessories clearly indicated.
- b. The minimum setting of the earth fault devices and the recommended setting for normal building operation.
- c. Sufficient information to show that switchboard overcurrent protection devices have been fully coordinated with load side overcurrent protection devices and the Supply Authorities primary overcurrent protection. This shall include time/current curves and trip settings.
- d. Equipment room layout showing switchboards, panel boards, motor control centres, etc., with required clearances as specified in the SANS codes.

### **EA8.4 Installation**

- a. Install switchboard where shown, in accordance with the manufacturer's written instructions and recognized industry practices to ensure that the switchboards comply with the requirements and serve the intended purposes.
- b. Install switchboard on a nominal 100 mm high reinforced concrete housekeeping pad. The housekeeping pad shall extend 80 mm beyond the housing of the switchboard unless shown otherwise. The entire assembled switchboard shall be anchored to continuous 40 mm x 150 mm channels for the full length.
- c. The channels shall be embedded in the concrete housekeeping pad. Bolt studs shall be at least 10 mm in diameter and located not more than 750 mm apart centre to centre. The mounting channels shall be continuous single-piece structural channels and shall be levelled when embedded in the concrete housekeeping pads. The channel and bolt studs shall be furnished and installed by the Electrical Contractor.

### **EA8.5 Equipment of Switchboards and Distribution Kiosks**

- a. The fault-breaking capacity of each breaker shall be certified by IEC test to be not less than the prospective fault levels marked on the wiring schedules. When used as main L.T. switches protecting transformers, they shall be submitted to the Supply Authority for trip testing.
- b. Moulded case circuit-breakers shall comply with IEC 157-1 or SANS 156:2007 as amended, shall be of fixed or draw-out execution as set out in the Project Specification. It shall have fault-breaking capacities certified by I.E.C. test to be equal to or greater than the prospective fault levels marked on the wiring schedules. Wherever possible, circuit breakers shall bear the SABS mark.

- c. Miniature circuit-breakers shall comply with SANS 156:2007 as amended and shall bear the SABS mark. The fault-breaking capacity of miniature circuit breakers shall be certified by SABS test to be not less than the values set out in the wiring schedules.
- d. Current-limiting circuit breakers, suitably certified, are acceptable in all cases.
- e. In general circuit-breaker overload trip systems of the thermal or hydraulic-magnetic types are equally acceptable. In cases where high ambient temperatures or widely varying extremes of ambient temperature are expected hydraulic-magnetic devices shall be preferred: alternatively, thermal devices with ambient temperature compensation may be offered. Where circuit breakers have to sustain motor-starting currents and the like, circuit breakers shall be hydraulic-magnetic with appropriate tripping characteristics. Where described in the Project Specification as being for short-circuit protection only, the circuit breakers shall be supplied without overload trip devices.
- f. Switches shall comply with the requirements of SANS 60947 as amended and shall be capable of safely making onto fault currents of the magnitudes shown on the wiring schedules. Main switches of distribution boards shall additionally comply with the requirements of SANS 60947 applicable to switch-disconnectors. The main switches shall be rated for uninterrupted duty. Other switches shall be rated for 8-hour duty - the utilization category shall in all cases be AC22. All switches and switch-disconnectors shall bear the SABS mark.
- g. Contactors shall comply with SANS 60947 and shall be rated to perform not less than 1 000 000 operations at the current ratings and duties quoted on the wiring schedules. They shall be so fixed as to ensure adequate coil ventilation. Contactors shall comply with the detailed requirements set out later in this Specification.
- h. The internal wiring of switchboards shall be done with colour-coded PVC-insulated stranded conductors and shall include all phase, neutral, earth and control wires between equipment and to terminal blocks. Wiring channels shall be made spacious enough to permit the easy passage of all circuit wiring with adequate spacing between different circuits to promote ventilation. All the wires of each circuit or sub-circuit shall be braided together with approved strapping and shall be so arranged as to permit any individual circuit to be examined or renewed without disturbing any other circuits. Stranded conductors shall be terminated in crimped lugs of ferrules; manual crimping shall be done with makers' special tools which will not release until the full crimping pressure has been achieved; the ends of conductors from 50mm<sup>2</sup> cross-sectional areas upwards shall be crimped by hydraulic machine.

#### **EA8.6 Spare Space**

All distribution boards shall be of adequate size to accommodate specified equipment and a minimum of 30% spare capacity shall be allowed for future equipment unless specifically stated in the detail specification.

#### **EA8.7 Labels and Legends**

- a. All labels shall be of plastic "sandwich board" material, the legends being engraved through the front plastic layer to the contrasting inner layer.
- b. The lettering of legends shall not be less than 6mm high in sans-serif capitals; white lettering on black ground or black lettering on white ground shall be selected as necessary to ensure maximum legibility and contrast with the switchboard finish. All labels shall be secured by at least two bolts or rivets per label and shall be accurately level and central over their subjects.

#### **EA8.8 Busbars**

Bus bars shall be of copper or aluminium and shall comply with SANS 1195 as amended. Copper bus bars shall be tinned after fabrication; the current ratings shall be those assigned by the Copper

Development Association. Multiple bars shall be arranged with air gaps between the sections, equal to the section thickness. Insulating busbar supports shall be provided at intervals related to the prospective short-circuit fault currents. COLOUR FINISH

The front panels of normal supply, standby power and no-break supply sections shall be painted in distinctive colours as follows:

- a. Normal supply : Light Orange, colour B26 of SANS 1091.
- b. Standby power : Signal Red, colour A11 of SANS 1091.
- c. UPS supply: Light Blue, colour of SANS 1091.

**Note:** Refer to the DB schematic for details. The DB manufacture to supply three (3) x sets of drawings for approval prior to manufacture.

#### **EA8.9 Recessed and Semi-Recessed Distribution Boards**

##### **G. Distribution boards shall consist of the following parts:**

The bonding tray shall be constructed from 1,60 mm corrosion resistant mild sheet steel. Bracing gussets with cam-shaped slots shall be welded on the four corners. Knockouts shall be provided in the upper and lower sides of the distribution boards. Expanded metal shall be spot-welded to the back of all bonding trays for 102,5 mm thick walls.

##### **H. Architrave frame**

- a. The architrave frame shall be constructed from 1,20 mm sheet steel with square edges.
- b. The architrave frame shall form 25 mm border around bonding tray and shall be fixed to the tray in such a manner as to allow for adjustment for the inequalities in wall the finish.
- c. A minimum of 75 mm shall be allowed between the inside of the architrave frame and the equipment.
- d. Distribution board numbers consisting of white engraved lettering on a black background shall be fixed to the top of the architrave frame.

##### **I. Doors**

- a. Doors shall be constructed from 1,20 mm sheet steel, reinforced to ensure rigidity.
- b. Doors shall be mounted flush in architrave frames. Door catches shall be constructed of chromium-plated brass and shall be mounted flush in the door. Built-in locks shall be provided when specified in the distribution board schedule.

##### **J. Chassis**

The chassis shall be fixed to the architrave frame. The chassis shall be reinforced, with the necessary provision for fixing of the switchgear. A distance of 75 mm shall be allowed between rows of equipment.

##### **K. Panels**

Panels shall be rigidly constructed from 1,6 mm sheet steel with machine-cut openings for flush mounted equipment. Panels shall be fixed to the architrave frame on studs with chromium plated hexagon dome headed nuts, or captive fasteners such that a clearance of 40 mm is maintained between panels and doors. Chromium-plated handles shall be supplied to facilitate removal of panels.

**L. Busbars**

- a. Busbars shall be of tinned HDHC solid copper with adequate cross-section and shall only be supplied if called for in the Schedules. Busbars are to be mounted on suitable isolators and shall be drilled and tapped.
- b. Each distribution board shall be supplied with copper neutral and earth bars. Adequate terminals shall be provided.
- c. Each busbar must be supplied with one larger terminal for the feeder cable.

**M. Wiring**

- a. Wiring shall be by means of PVC insulated conductors with sizes to suit the relevant switchgear. The ends of wires shall be provided with suitable lugs, firmly crimped, or soldered for connection to busbars.
- b. Wiring shall, where possible, be carried out in front of the chassis and shall be neatly bound in horizontal and vertical rows by means of approved plastic cable ties. Wiring shall be kept free of any current carrying parts.
- c. Ends of wires which are connected to the clamps of miniature circuit breakers, shall be turned together firmly before insertion into terminals.

**N. Finish**

Welding joints and steelwork shall be ground smooth and free from blemishes.

Metal components of the framework, panels, and chassis shall be painted in accordance with the procedure detailed below. Baked enamel or electrostatically applied powder coating may be used.

**a. Surface preparation.**

Prior to painting, all metal parts shall be thoroughly cleaned of rust, mill scale, grease, and foreign matter to a continuous metallic finish. Sand or shot blasting, or acid pickling and washing may be employed for this purpose.

**b. Baked enamel finish.**

Immediately after cleaning all surfaces shall be covered by a rust inhibiting, tough, unbroken metal phosphate film and then thoroughly dried to SANS 10064. Within forty-eight (48) hours after phosphating, a passivating layer consisting of a high-quality zinc chromate primer shall be applied, followed by two (2) coats of high quality baked enamel to SANS 2808 Codes. The minimum paint thickness after baking shall be 0,6 mm. The paint shall have a shock resistance of 25 kg-cm on 0,9 mm soft steel plate and a scratch resistance of 2 kg.

**c. Powder coated finish.**

Immediately after cleaning the metal parts shall be pre-heated and then covered by a micro structured paint powder applied electrostatically. The paint shall be baked on and shall harden within 10 minutes at a temperature of 190oC. The minimum paint thickness after baking shall be 0,05 m and the paint cover shall have a shock resistance of 25 kg-cm on 0,9 mm soft steel plate and a scratch resistance of 2 kg.

**EA8.10 Surface Mounted Distribution Boards**

Surface mounted distribution boards shall comply with SANS 60456 and shall be similar to the specification for flush mounted boards, except that the architrave frames and bonding trays are not required. In this case a box shall be supplied manufactured from 1,60 mm corrosion resistant sheet



steel with knockouts at the top and bottom for conduit entry. The board shall have a 25 mm wide frame around the flush mounted door, if required.

#### **EA8.11 Training**

Installation of the switchgear shall require no special tools. Product training shall be made available at the purchaser's facility if required.

### **EA9 CONDUIT AND OUTLET BOXES**

#### **EA9.1 Quality Assurance**

##### **EA9.1.1 Codes and Standards**

The conduit and conduit accessories shall comply fully with the applicable SANS specifications as set out below and the conduit shall bear the mark of approval of the South African Bureau of Standards.

- a. The latest issue of SANS 60614 and SANS 61035, parts 1 and 2: Metallic conduit and accessories
- b. The latest issue of SANS 950: Non-metallic conduit and accessories

##### **EA9.1.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

##### **EA9.1.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

#### **EA9.2 Conduit and Accessories**

- a. The type of conduit and accessories required for the service, i.e. whether the conduit and accessories shall be of the screwed type, plain-end type or of the non-metallic type and whether metallic conduit shall be black enamelled or galvanised, is specified in the particular specification.
- b. Electrical and ICT distribution within buildings shall be as follows:
  - Cable trays – in open areas and accessible ceilings
  - Cable Baskets – in accessible ceilings
  - PVC Conduits – in accessible ceilings and hidden conduits
  - Galvanised steel conduits – exposed and surface mounted
- c. Unless other methods of installation are specified for certain circuits, the installation shall be in conduit throughout. No open wiring in roof spaces or elsewhere will be permitted.
- d. All conduit fittings, except couplings, shall be of the inspection type. Where cast metal conduit accessories are used, these shall be of malleable iron. Zinc base fittings will not be allowed.

- e. Bushes used for metallic conduit shall be provided in addition to locknuts at all points where the conduit terminates at switchboards, switchboxes, draw-boxes, etc.
- f. Draw-boxes are to be provided in accordance with the "Wiring Code" and wherever necessary to facilitate easy wiring.
- g. For light and socket outlet circuits, the conduit used shall have an external diameter of 20mm. In all other instances the sizes of conduit shall be in accordance with the "Wiring Code" for the specified number and size of conductors, unless otherwise directed in the particular specification or indicated on the drawings.
- h. Only one manufactured type of conduit and conduit accessories will be permitted throughout the installation.
- i. Running joints in screwed conduit are to be avoided as far as possible and all conduit systems shall be set or bent to the required angles. The use of normal bends must be kept to a minimum with exception of larger diameter conduits where the use of such bends is essential.
- j. Under no circumstances will conduit having a wall thickness of less than 1,6mm be allowed in screeding laid on top of concrete slabs.
- k. Bending and setting of conduits must be done with special bending apparatus manufactured for the purpose and which are obtainable from the manufacturers of the conduit systems. Damage to conduit resulting from the use of incorrect bending apparatus or methods applied must on indication by the Engineers inspectorate staff, be completely removed and rectified and any wiring already drawn into such damaged conduits must be completely renewed at the Contractor's expense.
- l. Conduit and conduit accessories used for flame-proof or explosion proof installations and for the suspension of luminaires as well as all load bearing conduit shall in all instances be of the metallic screwed type.
- m. All conduit and accessories used in areas within 50 km of the coast shall be galvanised to SANS specifications.
- n. Tenderers must ensure that general approval of the proposed conduit system to be used is obtained from the local electricity supply authority prior to the submission of their tender. Under no circumstances will consideration be given by the Employer to any claim submitted by the Contractor, which may result from a lack of knowledge in regard to the supply authority's requirements.

### **EA9.3 Screwed Metallic Conduit and Accessories**

- a. Screwed metallic conduits shall comply with SANS 60614 and shall bear the SABS mark. Screwed metallic conduits shall comprise of a heavy gauge, welded or solid drawn, black enamelled or hot-dipped galvanised, screwed steel tube.
- b. Galvanised conduits shall be hot dipped on both the inside and outside thereof, in accordance with SANS 121.
- c. All conduit ends shall be reamed and threaded on both sides and shall be delivered to site with a steel coupling fitted at one end and a plastic screw on cap on the opposite end.
- d. All screwed metallic conduit accessories shall be of malleable cast iron or pressed steel with brass bushes and all accessories shall be in accordance with SANS 60614 Part II. No alloy or pressure cast metal accessories or zinc base alloy fittings will be accepted.
- e. All accessories whether galvanised or black enamelled shall be supplied with brass screws.
- f. Locknuts are to be of the narrow, hexagonal type. Ring type lock nuts shall not be accepted except when used in round grouping boxes.
- g. Bushnuts and male or female conduit bushes shall be manufactured from solid brass. Brass alloy bushnuts and bushes shall not be accepted.

- h. In general, screwed steel conduit shall be used in the wiring of buildings. The installation shall conform to requirements of SANS 10142. All joints in conduit tubing shall be red leaded to prevent rust. Galvanised conduit and accessories shall be used in the following circumstances and normally be electro-galvanised or cadmium plated:
- In damp areas
  - In areas exposed to the weather
  - For all installations within 50 km of the coast. (These conduits and accessories shall be hot dip galvanised to SANS 121).
  - In plenum chambers containing humidifying equipment.
  - For surface mounted conduit installations in kitchens and boiler rooms.
  - In screed resting directly on soil.
  - For connection points to future installations.
  - For underground conduit containing earthing conductors.
  - In buildings where animals are housed such as cattle, sheep, dogs, etc.
- i. Screwed conduits shall be terminated by means of a brass female bush and two lock nuts in pressed steel switchboards and distribution boxes, cable ducts, power skirting, etc. The conduit end shall only project far enough through the hole to accommodate the bush and locknut.
- j. A female bush and two lock nuts shall be used to terminate conduits at draw boxes and outlet boxes without spouts should there be sufficient room in the box. Where there is insufficient room, a coupling, brass male bush and locknut may be used with sufficient allowance for the reduction of the internal diameter by the male bush. Mechanical and electrical continuity shall be maintained throughout the conduit installation. The resistance of a completed joint shall not exceed 0,2 ohm. Under no circumstances shall conduit be relied upon for earth continuity.

#### **EA9.4 Plain-End Metallic Conduit and Accessories**

- a. As an alternative to threaded metallic conduit, plain-end or unthreaded metallic conduit and accessories may be used. Plain-end conduit shall be manufactured from mild steel having a minimum wall thickness of 0,9 mm and shall comply with SANS 60614. Bending and setting of plain-end conduit shall be undertaken using the correct bending apparatus as recommended by the manufacturer of the conduit.
- b. Galvanised conduits shall be hot dipped on both the internal and external surfaces, in
- c. accordance with SANS 121. All plain-end metallic conduit accessories shall be of malleable cast iron or pressed steel and shall comply to SANS 60614.
- d. Where specified plain-end conduit shall be installed. The following shall apply:
- e. Bending and setting of plain-end conduit shall be done with special benders and apparatus manufactured for this purpose. Damaged conduit resulting from the use of incorrect bending apparatus shall be completely removed and rectified at the electrical contractor's expense.

#### **EA9.5 PVC Conduit and Accessories**

- a. PVC conduit shall comply with SANS 950 and shall bear the SABS mark. PVC conduit shall be constructed from rigid PVC and shall be supplied in standard 4 metre lengths. PVC conduit shall be white in colour and shall be non-inflammable. The minimum softening temperature shall be at 75°C.
- b. All PVC conduit accessories shall be fully in accordance with SANS 950 and shall bear the SABS mark.
- c. Where specified for a particular service, PVC conduit shall be installed.

- d. All PVC conduit shall be installed in accordance with SANS 950. Insulated heat-resistant boxes shall be used for outlets of totally enclosed luminaires and other fittings where excessive temperatures are likely to occur. Luminaires and other fittings shall not be supported by PVC conduit or conduit boxes.
- e. These fittings shall be secured to the surrounding structure in an acceptable way.

#### **EA9.6 Flexible Conduit**

- a. Flexible steel conduit and adaptors shall comply with BS 731, part 1 where applicable. Flexible steel conduit shall be of a galvanised steel construction which is not required to be waterproof but shall be vermin proof and suitable for protection of cables against mechanical damage. In moist or damp areas flexible steel conduit shall be of the plastic sheathed galvanised steel type. Flexible polypropylene tubing shall only be fastened to PVC conduit installations.
- b. In installations where the equipment has to be moved frequently to enable adjustment during normal operation, for the connection of motors or any other vibrating equipment, for the connection of thermostats and sensors on equipment, for stove connection and where otherwise required, flexible conduit shall be used for the final connection to the equipment.
- c. Flexible conduit shall be connected to the remainder of the installation by means of a draw box. The flexible conduit may be connected directly to the end of a conduit if an existing draw box is available within 2 m of the junction and if the flexible conduit can easily be rewired.
- d. Flexible conduit shall consist of metal reinforced plastic conduit or PVC covered metal conduit with an internal diameter of at least 15 mm, unless approved to the contrary. In false ceiling voids, flexible conduit of galvanised steel constructions may be used. Connectors for coupling to the flexible conduit shall be of the gland or screw-in type, manufactured from either brass or mild steel plated with zinc or cadmium.

#### **EA9.7 Earth Clamps**

Earth clamps shall comprise of copper strips having a minimum thickness of 1 mm and shall not be less than 12 mm wide. Earth clamps shall be provided complete with a 25 mm x 4 mm brass bolt, washer and nut and shall be constructed so that the clip can be firmly attached to the conduit without the need for any additional packing.

#### **EA9.8 Flush Mounted Steel Wall Boxes**

Flush mounted steel wall boxes shall be manufactured from heavy gauge sheet steel and shall be galvanised. All wall boxes shall comply with SANS 1085. The boxes shall be provided with the necessary mounting lugs to suite the units for which the box is intended. Mounting highs shall be drilled and tapped at 82,5 mm centres suitable for fastening either flush mounted switch and socket outlet units. All fastening screws shall be provided with the box. Single gang wall boxes shall be approximately 500 mm wide by 100 mm long by 50 mm deep, with one knock-out at each end and at the back, and with two knockouts on each side thereof. Double gang wall boxes shall be approximately 100 mm wide by 100 mm long by 50 mm deep, with two knockouts on each end and with at least two knockouts on the back, and on each side. All knockouts are to be suitable for making-off 20 mm diameter conduits.

#### **EA9.9 Flush Mounted PVC Wall Boxes**

- a. Flush mounted PVC wall boxes shall be manufactured from rigid PVC and shall be white in colour. All PVC wall boxes shall comply with SANS 950. The boxes shall be provided with the

necessary mounting lugs to suite the units for which the box is intended. Mounting lugs shall be drilled at 82,5mm centres and shall be provided with no 6 screw threads.

- b. The boxes shall be of approximately the same physical dimensions as those specified for steel wall boxes and shall have 20 mm knockouts. Facilities shall be provided for the fixing of earth terminals to the box.

#### **EA9.10 Round Group-Type Steel Boxes**

- a. The boxes shall be manufactured in accordance with SANS 1085 where applicable. The boxes shall be of the long spout pattern and shall be constructed from either store enamelled jet black or galvanised steel, or from malleable cast iron. The two cover fixing holes shall be diagonally opposite each other and shall be drilled and tapped at 50 mm centres. The internal dimensions shall be approximately 60 mm in diameter by 60 mm deep for use in concrete work. Shallower boxes shall be used in open roof spaces.
- b. Threaded spouts shall be suitable for 20 mm diameter conduit. Round box covers shall be constructed from pressed enamelled or galvanised steel and shall be sealed by using brass screws.

#### **EA9.11 Round Group-Type PVC Boxes.**

The boxes shall be similar in shape to those specified for steel boxes and shall have spouts which are to be reinforced with webs. The cover screw pillars shall be provided with tapped brass inserts and provision shall be made for a brass earthing terminal adjacent to one or both of the pillars. PVC round box covers shall be of PVC and shall be secured by means of 2 cadmium plated or brass screws at 50 mm centres. The boxes shall be fully in accordance with SANS 950.

#### **EA9.12 Draw Wires**

All draw wires for unused conduits shall comprise of galvanised steel wire having a minimum diameter of 2 mm.

#### **EA9.13 Installation Requirements**

All accessories such as boxes for socket outlets, switches, lights, etc shall be accurately positioned. It is the responsibility of the electrical contractor to ensure that all accessories are installed level and square at the correct height from the floor, ceiling or roof level as specified. It shall be the responsibility of the electrical contractor to determine the correct final floor, ceiling, and roof levels in conjunction with the principle contractor. Draw boxes shall not be installed in positions where they will be inaccessible after completion of the installation. Draw boxes shall be installed in inconspicuous positions to the approval of the engineer's representative and shall be indicated on the "as built" drawings. Galvanised steel draw wires shall be installed in all unwired conduit, e.g., conduits for future extensions, telephone installations and other services. The edge of flush mounted outlet boxes shall not be deeper than 10 mm from the final surface. Spacer springs shall be used under screws where necessary. Oversize cover plates shall be provided on all flush mounted round conduit boxes, where required. Surface mounted boxes shall be provided with standard size cover plate.

#### **EA9.14 Installationi Concrete**

- a. In order not to delay building operations, the electrical subcontractor shall ensure that all conduits and accessories which are to be cast in concrete are placed in position in good time. The electrical contractor or his representative shall be in attendance when the concrete is cast.

Draw boxes, expansion joints and round ceiling boxes shall be installed where required and shall be finished to match the finished slab and wall surfaces. Ceiling draw boxes shall be of the deep type. In columns where flush mounted draw boxes are installed, the conduits shall be offset from the surface of the column immediately after leaving the draw box. Elbows for conduits of 32 mm diameter and smaller and sharp bends will not be allowed in concrete slabs.

- b. Draw boxes and/or inspection boxes shall, where possible, be grouped together under a common approved cover plate. The cover plate shall be secured by means of screws. All conduits shall be installed as close as possible to the neutral axis of concrete beams, slabs, and columns. The conduits shall be rigidly secured to the reinforcing to prevent movement towards the surface of the concrete.
- c. All conduits, draw boxes etc, shall be securely fixed to the shuttering to prevent displacement when concrete is cast. Draw boxes and outlet boxes shall preferably be secured by means of a bolt and nut installed from the back of the box through the shuttering. Fixing lugs may also be used to screw the boxes to the shuttering where off-shutter finishes are required. Where fibre glass shuttering is used by the builder, the equipment shall be fixed to the steel only and no holes shall be drilled or made in shuttering. All draw boxes and outlet boxes shall be plugged with wet paper before they are secured to the shuttering.
- d. As far as possible, conduits shall not be installed across expansion joints. Where this is unavoidable a conduit expansion joint shall be provided. The expansion joint shall consist of two draw boxes with an interlinking flexible conduit connection. The draw box shall be installed adjacent to the expansion joint of the structure and a conduit sleeve, one size larger than that specified for the circuit, shall be provided on the side of the draw box nearest to the joint. The one end of the sleeve shall terminate at the edge of the joint and the other shall be secured to the draw box. The circuit conduit passing through the sleeve shall be terminated 40 mm inside the draw box and in the case of metallic conduit, the conduit end shall be fitted with a brass bush.
- e. The gap between the sleeve and the conduit at the joint shall be sealed with a suitable and approved sealing compound, to prevent the ingress of wet cement. In the case of metallic conduit, an earth clip shall be fitted to the conduit projection inside the draw box and the conduit bonded to the box by means of 2,5 mm<sup>2</sup> bare copper earth wire and a brass bolt and nut. The other end of the circuit conduit shall be secured to the draw box by means of lock nuts and a brass bush in the case of screwed metallic conduit or a standard bushed adaptor for other conduit types. In addition to an earth wire which may be specified for the circuit, a 2,5 mm<sup>2</sup> bare copper wire shall be provided between the first conduit box on either side of the joint in the case of metallic conduit. The conduit boxes shall be drilled and tapped, and the earth wire shall be bonded to the boxes by means of lugs and brass screws. Suitable steel cover plates shall be screwed to draw boxes installed along the expansion joint. The cover plates shall be installed before the ceiling is painted. Where a number of conduits are installed in parallel they shall cross the expansion joint of the structure via a single draw box. A number of draw boxes adjacent to each other will not be allowed. The installation of conduits in floor screed shall be kept to a minimum. Where conduits are installed in screed, the top of the conduit shall be at least 20 mm below the surface of the screed. Where the screed is laid directly on the ground, galvanised conduits shall be used. A minimum distance of twice the outside diameter of the conduit shall be left free between adjoining conduits. Conduits shall be secured to the concrete slab at intervals not exceeding 2,0 m. The electrical contractor shall ensure that conduits are not visible above the screed where the conduits leave the screed. All draw boxes, conduits, etc, which are installed in concrete shall be cleaned with compressed air and provided with draw wires two days after removal of the shuttering.

- f. Errors that occurred during the installation of the conduits, or any lost draw boxes, or blocked conduits shall be immediately reported to the engineer and confirmed in writing in order that an alternative route can be planned and approved by the engineer before the additional concrete is cast. Where it is necessary to cut or drill holes in the concrete structure, prior permission shall be obtained from the engineer in writing.

#### **EA9.15 Installation in Brickwork**

Recessed conduits and accessories installed in brickwork shall be built in. In order not to delay building operations the electrical contractor shall ensure that all conduits and accessories which are to be built-in are placed in position in good time. Any conduits, draw boxes, outlet boxes etc, which have been damaged, lost or omitted shall immediately be reported to the engineer by telephone and confirmed in writing.

#### **EA9.16 Chasing and Builder's Work**

- a. Except where otherwise specified the builder or principle contractor shall be responsible for building in of conduits, outlet boxes, switchboard trays, bonding trays, and other wall outlet boxes. The electrical contractor shall notify the builder of his requirements and the responsibility lies with the electrical contractor to ensure that all builder's work is clearly indicated or marked where necessary and provided in accordance with his requirements.
- b. Electrical materials to be built in must be supplied, placed, and fixed in position by the electrical contractor when required to do so by the builder or principle contractor. The electrical contractor shall also ensure that these materials are installed in the correct positions.
- c. Unless specifically stated to the contrary in the detail specification all flush mounted conduits, accessories, switchboard trays, bonding trays etc, shall be built-in and no chasing shall be allowed.

#### **EA9.17 Mounting Height of DB's, Switches and Socket Outlets**

- a. Except where stated otherwise, mounting heights shall be as follows:
  - Distribution boards: top frame 2000 mm above finished floor level
  - Switches: underside 1400 mm above finished floor level
  - Socket outlets: underside 300 mm above finished floor level
  - Telephone outlets: underside 300 mm above finished floor level
  - Power skirting: underside 100 mm above finished floor level
- b. All distribution boards, switches and socket outlets shall be of the flush mounted type except where stated otherwise.

#### **EA9.18 Position of Outlets, Equipment and Conduit**

Position of light outlets indicated on the plans are approximate. The exact positions of light outlets shall be determined with due regard to ceiling squares, branding and patterns. Where any doubt arises as to the correct location of outlets, the engineer and/or architect shall be consulted. The positions of other outlets, equipment and conduit are also approximate. The exact positions shall be determined on site in consultation with the engineer and/or architect.

**EA9.19 Conduit in Roof Spaces**

- a. Conduit in roof spaces shall be installed parallel or at right angles to the roof members and shall be secured at intervals not exceeding 1,5m by means of saddles or conduit clips nailed to the roof timbers.
- b. Where non-metallic conduit has been specified for a particular service, the conduit shall be supported and fixed with saddles with a maximum spacing of 450 mm. The Contractor shall supply and install all additional supporting timbers in the roof space as required.
- c. Under flat roofs, in false ceilings or where there is less than 0,9m of clearance, or should the ceilings be insulated with glass wool or other insulating material, the conduit shall be installed in such a manner as to allow for all wiring to be executed from below the ceilings.
- d. Conduit runs from distribution boards shall, where possible terminate in fabricated sheet steel draw-boxes installed directly above or in close proximity to the boards.
- e. All conduits shall be installed horizontally or vertically as determined by the route. The electrical contractor shall take all measures to ensure a neat installation. Conduits shall be firmly secured by means of saddles and screws and in accordance with SANS 10142. Conduits shall be secured within 150 mm before and after each 90o bend. Only approved plugging materials such as fibre plugs or plastic plugs, etc, and round head brass screws shall be used when fixing saddles, switches, plugs etc, to walls. Wood plugs are not acceptable nor should plugs be installed in joints in brick walls.

**EA9.20 Surface Mounted Conduit**

- a. Wherever possible, the conduit installation is to be concealed in the building work; however, where unavoidable or otherwise specified under the particular specification, conduit installed on the surface must be plumbed or levelled and only straight lengths shall be used.
- b. The use of inspection bends is to be avoided and instead the conduit shall be set uniformly and inspection coupling used where necessary.
- c. No threads will be permitted to show when the conduit installation is complete, except where running couplings have been employed.
- d. Running couplings are only to be used where unavoidable, and shall be fitted with a sliced couplings as a lock nut.
- e. Conduit is to be run on approved spaced saddles rigidly secured to the walls.
- f. Alternatively, fittings, tees, boxes, couplings etc., are to be cut into the surface to allow the conduit to fit flush against the surface. Conduit is to be bedded into any wall irregularities to avoid gaps between the surface and the conduit.
- g. Crossing of conduits is to be avoided, however, should it be necessary purpose-made metal boxes are to be provided at the junction. The finish of the boxes and positioning shall be in keeping with the general layout.
- h. Where several conduits are installed side by side, they shall be evenly spaced and grouped under one purpose-made saddle.
- i. Distribution boards, draw-boxes, industrial switches and socket outlets etc., shall be neatly recessed into the surface to avoid double sets.
- j. In situations where there are no ceilings the conduits are to be run along the wall plates and the beams.
- k. Painting of surface conduit shall match the colour of the adjacent wall finishes.
- l. Only approved plugging materials such as aluminium inserts, fibre plugs, plastic plugs, etc., and round-head screws shall be used for fixing saddles, switches, socket outlets, etc., to walls, wood plugs and the plugging in joints in brick walls are not acceptable.



**EA9.21 Flexible Connectionsf Connecting up of Stoves, Machines, Etc.**

- a. Flexible tubing connections shall be of galvanised steel construction, and in damp situations of the plastic sheathed galvanised steel type. Other types may only be used subject to the prior approval of the Employer's site electrical representative.
- b. Connectors for coupling onto the flexible tubing shall be of the gland or screw-in types, manufactured of either brass or cadmium or zinc plated mild steel, and the connectors after having been fixed onto the tubing, shall be durable and mechanically sound.
- c. Aluminium and zinc alloy connectors will not be acceptable.

**EA9.22 Wiring**

- a. Except where otherwise specified in the particular specification, wiring shall be carried out in conduit throughout. Only one circuit per conduit will be permitted.
- b. No wiring shall be drawn into conduit until the conduit installation has been completed and all conduit ends provided with bushes. All conduits to be clear of moisture and debris before wiring is commenced.
- c. Unless otherwise specified in the particular specification or indicated on the service drawings, the wiring of the installation shall be carried out in accordance with the "Wiring Code". Further to the requirements concerning the installation of earth conductors to certain light points as set out in the "Wiring Code", it is a specific requirement of this document that where plain-end metallic conduit or non-metallic conduit has been used, earth conductors must be provided and drawn into the conduit with the main conductors to all points, including all luminaires and switches throughout the installation.
- d. Wiring for lighting circuits is to be carried out with 1,5mm<sup>2</sup> conductors and a 1,5mm<sup>2</sup>-earth conductor. For socket outlet circuits the wiring shall comprise 4mm<sup>2</sup> conductors and a 2,5mm<sup>2</sup>-earth conductor. In certain instances, as will be directed in the particular specification, the sizes of the aforementioned conductors may be increased for specified circuits. Sizes of conductors to be drawn into conduit in all other instances, such as feeders to distribution boards, power points etc., shall be as specified elsewhere in this specification or indicated on the drawings. Sizes of conductors not specified must be determined in accordance with the "Wiring Code".
- e. The loop-in system shall be followed throughout, and no joints of any description will be permitted.
- f. The wiring shall be done in PVC insulated 600/1000 V grade cable to SANS 60227.
- g. Where cable ends connect onto switches, luminaires etc., the end strands must be neatly and tightly twisted together and firmly secured. Cutting away of wire strands of any cable will not be allowed.

**EA9.23 Switches and Socket Outlets**

- a. All switches and switch-socket outlet combination units shall conform to the Employer Quality Specifications, which form part of this specification.
- b. No other than 16 A 3 pin sockets are to be used unless other special purpose types are distinctly specified or shown on the drawings.
- c. All light switches shall be installed at 1,4m above finished floor level and all socket outlets as directed in the Schedule of Fittings which forms part of this specification or alternatively the height of socket outlets may be indicated on the drawings.
- d. All switches, isolators and socket outlets shall be Lumex or Crabtree with plastic covers.

**EA10 STAND-BY / EMERGENCY GENERATOR****EA10.1 Scope****A. General**

Furnish and install Diesel Generators as shown, scheduled, and specified. Supply, deliver, install, commission, and test a standby generating set at the project site.

**B. Types**

The types of Diesel Generators include, but are not limited to, the following:

- a. Indoor 400 volt, Emergency Diesel Generator located in a generator room within a building. Size as indicated in the generator schedule.
- b. Outdoor 400 volt, Emergency Diesel Generator located in a fully rated outdoor enclosure. Size as indicated in the generator schedule.

**C. The specification scope covers the supply delivery, installation, and commissioning of the following:**

- a. Emergency Standby Diesel Generator
- b. Switchboard panel
- c. Change-over panel
- d. Room sound attenuation

**EA10.2 Quality Assurance****EA10.2.1 Codes and Standards**

The supply, delivery and installation of diesel generating sets shall comply fully with the applicable SANS specifications as set out below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS codes will be applicable:

- a. SANS 8528: Part 1-12: Reciprocating internal combustion engine driven alternating current generating sets.

**EA10.2.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

**EA10.2.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

**EA10.3 Emergency Standby Diesel Generator****EA10.3.1 Engine****A. General**

- a. The engine must comply with the requirements as laid down in SANS/ISO 8528 and must be of the atomised injection, compression ignition type, running at a speed not exceeding 1500 r.p.m. The engine must be amply rated for the required electrical output of the set, when running under the site conditions. The starting period for either manual or automatic switching-on until the taking over by the generating set, in one step of a load equal to the specified site electrical output, shall not exceed 15 seconds. This must be guaranteed by the Tenderer.
- b. Turbo-charged engines will only be accepted if the Tenderer submits a written guarantee that the engine can deliver full load within the specified starting period.

**B. Rating**

- a. The set shall be capable of delivering the specified output continuously under the site conditions, without overheating. The engine shall be capable of delivering an output of 110 % of the specified output for one hour in any period of 12 hours consecutive running in accordance with SANS/ISO 8528.
- b. The de-rating of the engine for site conditions shall be strictly in accordance with SANS/ISO 8528 as amended to date. Any other methods of de-rating must have the approval of the Engineer and must be motivated in detail. Such de-rating must be guaranteed in writing and proved by the successful Tenderer at the site test.

**C. Starting and Stopping**

- a. The engine shall be fitted with an electric starter motor and be easily started from cold, without the use of any special ignition devices under summer as well as winter conditions.
- b. Tenderers must state what arrangements are provided to ensure easy starting in cold weather. Full details of this equipment must be submitted. In the case of water-cooled engines, any electrical heaters shall be thermostatically controlled. The electrical circuit for such heaters shall be taken from the control panel and must be protected by a suitable circuit breaker.

**D. Starter Battery**

The set must be supplied with a fully charged lead-acid type battery, complete with necessary electrolyte. The battery must have sufficient capacity to provide the starting torque stipulated by the engine makers. The battery capacity shall not be less than 120 Ah and shall be capable of providing three consecutive start attempts from cold and thereafter a fourth attempt under manual control of not less than 20 seconds duration each. The battery must be of the heavy duty "low maintenance" type, house in a suitable battery box.

**E. Cooling**

- a. The engine may be either of the air or water-cooled type. In the case of water-cooling, a built-on heavy duty, tropical type pressurised radiator must be fitted. Only stand-by sets that are water cooled shall have electric heaters.
- b. For either method of cooling, protection must be provided against running at excessive temperatures. The operation of this protective device must give a visual and audible indication on the switchboard on the switchboard. Water-cooled engines shall in addition be fitted with a low water cut-out switch, installed in the radiator, to switch the set off in the event of a loss of coolant. The protection shall operate in the same way as the other cut-outs (e.g., low oil pressure). All air ducts for the cooling of the engine are to be allowed for. The air shall be supplied from the cooling fan cowling/radiator face to air outlet louvers in the plant room wall.

F. Lubrication

Lubrication of the main bearings and other important moving parts shall be by forced feed system. An automatic low oil pressure cut-out must be fitted, operating the stop solenoid on the engine and giving a visible and audible indication on the switchboard.

G. Fuel Pump

The fuel injection equipment is suitable for operation with the commercial brands of diesel fuel normally available in South Africa.

H. Fuel Tank

- a. A fuel tank shall be installed as part of the generator unit. The tank shall have sufficient capacity for standby sets to run the engine on full load for a period of 12 hours. The fuel tank shall be a free-standing type or part of the generator base unit.
- b. A water trap is fitted in the fuel pipeline from the tank to the engine.
- c. The tank shall be fitted with a suitable filter, a full height gauge glass, "low fuel level" alarm, giving an audible and visible signal on the switchboard as well as a low-low fuel level cut-out.
- d. An electrically operated pump with sufficient length of oil resistant hose to reach 2m beyond the door shall be supplied, for each set for filling the fuel tank/s from 200 litre drums.
- e. The interconnection fuel piping shall consist of copper tubes and the connection to vibrating components shall be in flexible tubing with armoured covering.

I. Governor

- a. The speed of the engine shall be controlled by a governor in accordance with class A2 of SANS/ISO 8528 if not otherwise specified in the specific requirements.
- b. The permanent speed variation between no load and full load shall not exceed 4,5% of the normal engine speed and the temporary speed variation shall not exceed 10% External facilities must be provided on the engine, to adjust the normal speed setting by  $\pm 5\%$  at all loads zero and rated load.

J. Flywheel

- a. A suitable flywheel must be fitted, so that lights fed from the set will be free from any visible flicker.
- b. The cyclic irregularity of the set must be within the limit laid down in SANS/ISO 8528.

K. Exhaust Silencer

- a. It is essential to keep the noise level as low as possible. An effective exhaust silencing system of the residential type must be provided.
- b. The exhaust pipe shall be installed in such a way that the expelled exhaust fumes will not cause discomfort to the public. The exhaust pipe must be flexibly connected to the engine to take up vibrations transmitted from the engine, which may cause breakage. The exhaust piping and silencer shall be lagged to reduce the heat and noise transmission into the plant room and shall be protected against the ingress of driving rain at  $45^\circ$  to the horizontal. The exhaust pipe must extend 0,5m above the roof gutters. It must be secured by flanges both sides of the wall at the point of exit. These flanges must be clamped to the wall with bolts through the wall.

L. Accessories

The engine must be supplied complete with all accessories, air and oil filters, 3 instruction manuals, spare parts lists, the first fill of all lubricating oils, fuel, etc.

**EA10.3.2 Alternator****A. General**

- a. The alternator shall be of the self-excited brush less type, with enclosed ventilated drip proof housing and must be capable of supplying the specified output continuously with a temperature rise not exceeding the limits laid down in SANS/ISO 8528 for rotor and stator windings.
- b. The alternator shall be capable of delivering an output of 110% of the specified output, for one hour in any period of 12 hours consecutive running.
- c. Both windings must be fully impregnated for tropical climate and must have an oil resisting finishing varnish.

**B. Regulation**

The alternator must preferably be self-regulated without the utilisation of solid-state elements. The inherent voltage regulation must not exceed plus or minus 5% of the nominal voltage specified, at all loads with the power factor between unity and 0,8 lagging and within the driving speed variations of 4,5% between no-load and full load.

**C. Performance**

The excitation system shall be designed to promote rapid voltage recovery following the sudden application of the load. The voltage shall recover to within 5% of the steady state within 300 milli-seconds following the application of full load and the transient voltage dip shall not exceed 18%.

**D. Coupling**

The engine and alternator must be directly coupled by means of a high-quality flexible coupling.

**EA10.4 Switchboard****A. General**

- a. A switchboard must be supplied and installed to incorporate the equipment for the control and protection of the generating set and battery charging.
- b. The switchboard must conform the specification as set out in the following paragraphs.

**B. Construction**

- a. The switchboard shall be a totally enclosed, floor mounted unit, fabricated from steel panels, carried on and-substantial angle iron framework.
- b. The board shall be flush fronted and all equipment to be mounted behind the front plate, on suitable supports.
- c. All equipment, connections and terminals shall be easily accessible from the front. The front panels may be either hinged or removable and fixed with studs and chromium-plated cap nuts. Self-tapping screws shall be used in the construction of the board.
- d. All pushbuttons, pilot lights, control switches, instrument, and control fuses, shall be mounted on hinged panels with the control wires in flexible looms.
- e. The steelwork of the boards must be thoroughly de-rusted, primed with zinc chromate and finished with two coats of signal red quality enamel, or a baked powder epoxy coating.
- f. Suitably rated terminals must be provided for all main circuits and the control and protection circuits. Where cable lugs are used, these shall be crimped onto the cable strands. Screw terminals shall be of the type to prevent spreading of cable strands. All terminals shall be clearly marked.
- g. For the control wiring, each wire shall be fitted with a cable or wire marker of approved type, and numbering of these markers must be shown on the wiring diagram on the

switchboard. Control wiring shall be run in PVC trunking. The trunking shall be properly fixed to the switchboard steelwork. Adhesives shall not be acceptable for the fixing of trunking or looms.

- h. The automatic control and protection equipment shall be mounted on a separate easily replaceable small panel with printed circuits. The equipment shall mainly be the "solid state" type. After mounting the equipment on the panel, the rear of this panel shall be sealed with epoxy-resin. However, other proven control systems may also be considered, but must be described in detail.
- i. All equipment on the switchboard, such as contactors, isolators, busbars, etc., shall have ample current carrying capacity to handle at least 110% of the alternator full load current.

C. Protection and Alarm Devices

- a. All switchboards shall be equipped with protection and alarm devices as described below.
- b. A circuit breaker and an adjustable current limiting protection relay must be installed for protection of the alternator. The protection relay shall be of the type with inverse time characteristics. The relay shall cause contactor to isolate the alternator and stop the engine.
- c. Protection must be provided for overload, high engine temperature, low lubricating oil pressure, over speed, start-failure, and low water level.
- d. Individual relays with reset pushed are required, to give a visible signal and stop the engine when any of the protective devices operate. In the case of manual operation of standby sets, it shall not be possible to restart the engine.
- e. The indicators and re-set pushes must be marked in English, as follows.

"OVERLOAD"
"TEMPERATURE HIGH"
"OIL PRESSURE LOW"
"OVER-SPEED"
"START FAILURE"
"LOW WATER LEVEL"

- f. In addition, two relays with reset pushes must be fitted giving and audible and visible signal when:
- g. The fuel level in the service tank is low. The reset push of this relay must be marked "FUEL LOW".
- h. In addition, a low-low level sensor must be provided. At this level the engine must stop to prevent air entering the fuel system.
- i. The battery charger failed. The reset push of this relay must be marked "CHARGER FAIL".
- j. This is also applicable to the engine driven generator/alternator.
- k. All relays must operate an alarm siren. A pushbutton must be installed in the siren circuit to stop the audible signal, but the fault indicating light on the control panel must remain lit until the fault has been rectified.
- l. An on/off switch is not acceptable. After the siren has been stopped, it must be re-set automatically, ready for a further alarm.
- m. The siren must be of the continuous duty and low consumption type. Both siren and protection circuits must operate from the battery.

- n. Potential free contacts from the alarm relay must be brought down to terminals for remote indication of alarm conditions.
- o. A test pushbutton must be provided to test all indicators lamps.

D. Manual Starting

Each switchboard shall be equipped with two pushbuttons marked "START" and "STOP" for manual starting and stopping of the set.

E. Battery Charging Equipment

- a. Each switchboard shall be equipped with battery charging equipment.
- b. The charger shall operate automatically in accordance with the state of the battery and shall generally consist of an air-cooled transformer, a full wave solid state rectifier, and the necessary automatic control equipment of the constant voltage system.
- c. The charger must be fed from the mains. An engine driven alternator must be also a provided for charging the battery while the set is operational. Failure of this alternator must also activate the battery charger failure circuit.

F. Switchboard Instruments

Each generating set shall have a switchboard equipped as follows:

- 3 x MDI ammeters and CT's
- Voltmeter and selector switch
- Emergency stop button (latchable)
- Frequency meter
- Hours run meter.
- Oil pressure gauge
- Engine temperature gauge
- Battery charger ammeter

G. Marking

All labels, markings or instructions on the switchgear shall be in English.

H. Earthing

- a. An earth bar must be fitted in the switchboard, to which all non-current carrying metal parts shall be bonded.
- b. The neutral point of the alternator must be solidly connected this bar by means of a removable link labelled "EARTH". Suitable terminals must be provided on the earth bar for connection of up to three earth conductors, which will be supplied and installed by others.

I. Operation Selector Switch

- a. A four-position selector switch must be provided on the switchboard marked "AUTO", "MANUAL", "TEST" and "OFF".
- b. With the selector on "AUTO", the set shall automatically start and stop, according to the mains supply being available or not.
- c. With the selector on "TEST", it shall only be possible to start and stop the set with the pushbuttons, but the running set shall not be switched to the load.
- d. With the selector on "MANUAL", the set must take the load when started with the pushbutton, but it must not be possible to switch the set on to the mains, or the mains onto the running set.
- e. With the selector on "OFF", the set shall be completely disconnected from the automatic controls, for cleaning and maintenance of the engine.

**EA10.5 Change-Over Panel****A. Automatic Change-over System**

These units will be provided to isolate the mains supply and connect the standby set to the outgoing feeder in case of a mains failure and reverse this procedure on return of the mains.

**B. By-pass Switch and Main Isolator**

The switchboard shall be equipped with an on-load isolator to isolate the mains and a manually operated on-load by-pass switch, which shall either connect the incoming mains to the automatic control gear or directly to the outgoing feeder. In the latter position the automatic control gear, including the main contractors, shall be isolated for maintenance purposes. It shall not be possible to start the engine except with the selector switch in the "TEST" position.

**C. Start Delay**

Starting shall be automatic in event of a mains failure. A 0-15 second adjustable start delay timer shall be provided to prevent start-up on power trips or noticeably short interruptions.

**D. Stop Delay**

A stop delay with timer is required for the set, to keep the set on load for an adjustable period of one to sixty seconds after the return of the mains supply, before changing back to the supply. An additional timer shall keep the set running for a further adjustable cooling period of 5 to 10 minutes at no-load before stopping.

The Generator supplier will be required to liaise and co-ordinate with the panel manufacturer so that the system operates as recorded above.

**EA10.6 Room Sound Attenuation****A. Room sound attenuation and vibration:**

Sound attenuation and anti-vibration mountings shall be provided to ensure that:

- The sound levels of not more than 70 dB are measured at a distance of 7m from the generator room.
- No vibration may be noticed in any other part of the building.

**B. Noise level**

Noise levels must be as per SANS 8528 - <68-70dB @ 7m.

**C. Sound attenuation requirements**

The following items must form part of the sound attenuation requirements.

All items must be supplied as part of the contract:

- a. Acoustic double door and single door as required.
- b. External weather louvers for intake and outlet openings. Colour as architectural requirements
- c. Sound attenuators for inlet and outlet air

**EA10.7 Installation****A. General**

- a. Except for the supply of the incoming mains cable and outgoing feeder cables, the tenderer must include for the complete installation and wiring of the plant in running order, including the connection of the incoming cable and outgoing feeder cables.



- b. The connecting of the cable and control cabling to the generator and the control terminals in the LV board remains the responsibility of the tenderer.

B. Load Acceptance

The generator set shall be capable of accepting 75% of the specified site electrical output 10 seconds after the starter motor is energised and the remaining 25%, 5 seconds thereafter, i.e. 100% load acceptance shall not exceed 15 seconds.

C. Generator Room

The size of the Generator Room will be as detailed in the generator room drawings.

D. Alarms

- a. The successful tenderer must pay particular attention to the requirements of the alarms as described in the Specific Requirements in this document.
- b. One alarm siren and red light shall be supplied and installed on the outside wall of the generator room in the position as shown on the drawing in this specification.
- c. The siren shall consist of an electronic unit similar and equal to a "Klaxon" - type SY2/725 siren with a continuously rated output and 110 DB at a distance of 2 metres and shall be IP55 weatherproof rated.
- d. The warning light shall consist of a 40W flashing red light, or equivalent, which shall be mounted on a galvanised steel frame together with the siren.
- e. The siren and light shall be switched on or off simultaneously after initiation or cancellation of an alarm condition. The supply and installation of the wiring between the control board and the alarm unit forms part of this contract.
- f. The successful tenderer must ensure that the siren control circuit resets automatically after cancellation due to a low fuel condition or battery charger failure, but the visible fault indication must remain, i.e., should the operator continue to run the set, the siren must sound, should any other condition develop.

E. Fuel Drip Tray

A drip tray approximately 100mm deep shall be mounted below the fuel tank and must be large enough to collect any fuel that drips from the tank accessories. The drip tray shall be manufactured from black mild steel. The thickness of the drip tray sheet steel shall not be less than 2mm.

F. Completion Time

The Generator Set is required to be commissioned in conjunction with the building contract.

G. Inform

The successful tenderer shall inform the Engineer when the set is ready for installation.

H. Fuel Supply Tank

- a. The fuel tank shall be a free-standing type, or part of the base, which shall be installed in the plant room. The tank shall have sufficient capacity for the generating set to run the engine on full load for a period of 12 hours.
- b. A drip tray approximately 100mm deep shall be mounted below the fuel tank and must be large enough to collect any fuel that drips from the tank accessories. The drip shall be manufactured from black mild steel with a thickness of not less than 2mm.

I. Generator cooling

Radiator cooling shall be provided, with adequate climate control to prevent overheating of the generator in the generator room.

**EA10.8 Control System**

- a. The unit to have a control panel with the following minimum indication and alarms:
  - Control Language, English
  - Warning - Low Battery Voltage
  - Warning - High Battery Voltage
  - Shutdown - Fail To Start
  - Shutdown - High AC voltage
  - Shutdown - Over/Under Voltage
  - Shutdown - Over/Under Speed
  - Warning & Shutdown – Engine temperature
  - Warning & Shutdown - Oil Pressure
  - Warning & Shutdown - Coolant Temperature
  - Warning & Shutdown – Fuel Level
  - Emergency Stop Switch – External
  - Display - Control LCD
- b. The system to be able to communicate to a building management or SCADA system via a PLC via Ethernet.

**EA10.9 Warning Notices**

- a. Notices, in English, must be installed in the plant rooms. The contents of these notices are summarised below:
  - Unauthorised entry prohibited.
  - Unauthorised handling of equipment prohibited.
  - Procedure in case of electric shock.
  - Procedure in case of fire.
- b. The successful tenderer must consult the Occupational Health and Safety Act 83 of 1993 and get approval of the wording from the Engineer's representative, prior to ordering the notices.
- c. Lettering must be black on a yellow background.
- d. Notices (a) must be installed outside next to the entrance of the plant room and (b-d) inside the plant room.
- e. In the plant room, a clearly legible and indelible warning notice must be mounted in a conspicuous position.
- f. The motive shall be made of a non-corrodible and non-deteriorating material, preferable plastic, and must read as follows:
  - DANGER: This engine will start without notice. Turn selector switch on control board to "OFF" before working on the plant.

**EA10.10 Construction**

- a. The engine and alternator of the set shall be built together on a common frame, which must be mounted on a skid base on anti-vibration mountings. The set must be placed direct on the concrete of the generator room. A drip tray must be fitted under the engine. The tray must be large enough to catch a drip from any part of the engine.
- b. The frame must be of the 'DUPLEX' type.

**EA10.11 Operation**

- a. The set is required to supply the lighting and power requirements in the case of a mains power failure.
- b. The set shall be fully automatic i.e., it shall start when any one phase of the main supply fails or get switched and shall shut down when the normal supply is re-established. In addition, it shall be possible to manually start and stop the set by means of pushbuttons on the switchboard.
- c. The automatic control shall make provision for three consecutive starting attempts. Thereafter the set must be switched off, and the start failure relay on the switchboard must give a visible and audible indication of the fault.
- d. To prevent the alternator being electrically connected to the mains supply when the mains supply is on and vice versa, a safe and fail proof system of suitably interlocked contactors shall be supplied and fitted to the changeover switchboard.

**EA10.12 Electrical Characteristics**Output and Voltage

After the de-rating factors for the engine and generator due to site conditions have been considered, the set must have a site output and voltage as follows:

No load voltage	:	400/230 Volt
Rating	:	As per Schedule
Power at 0,8 power factor	:	As per Schedule
Frequency	:	50Hz
Fault Level	:	5kA

**EA10.13 Drawing, Operating and Maintenance Instructions**

- a. Two copies of a fully detailed and dimensioned drawing of the recommended mounting plinth for the generator unit.
- b. Two copies of a dimensioned outline drawing of the generator unit (Plan and elevations).
- c. One paper copy and one electronic copy of the schematic wiring diagram of a typical generator unit, including change-over panel, switchboard, room attenuation and building requirements.

**EA10.14 Erection**

Installation arrangement — Skid unit with base.

**EA10.15 Pre-Delivery Information**

Within four weeks of receipt of the purchase order, the tenderer shall submit for the engineer's review, comment, and approve the following:

- Finalised schematic diagram and dimension drawings
- Operating characteristics of the transformer and protective devices.
- Shipping/ transport details.

**EA11 MOTOR CONTROL CENTRES****EA11.1 Quality Assurance**

Material and equipment shall be new and unused and of the best quality available.

**EA11.1.1 Codes and Standards**

SANS 1091: 2012	National colour standards for paint
SANS 10142-1: 2017	The wiring of premises: Low voltage installations
SANS 60269-2: 2016	Low voltage fuses: Supplementary requirements for fuses for use by authorised persons
SANS 60439-1: 2004	Low voltage switchgear and control gear assemblies: Type tested and partially type tested assemblies
SANS 60529: 2013	Degrees of protection provided by enclosures (IP code)
SANS 60947-3: 2016	Low voltage switchgear and control gear: Switches, disconnectors, switch disconnectors and fuse-combination units

**EA11.2 Overview**

The motor control centre (MCC) shall incorporate all equipment necessary for the control and protection of the electric motors.

Indoor panels shall be totally enclosed and flush fronted. Outdoor panels shall have an outer hinged door, free of equipment, providing a weatherproof enclosure for the inner door. All equipment shall be mounted within the panels and connections and terminals shall be easily accessible. Pilot lights, instrumentation, control switches etc. shall be mounted on a hinged door.

The MCC Panel and all associated electrical equipment offered must be rated to cater for a maximum ambient temperature of 50°C.

The incoming switch, control equipment, distribution equipment and starters shall be housed in separate metal enclosed panels.

With the starter main isolator in the OFF position there shall be no live wires entering the starter cubicle.

With the incoming main switch in the OFF position there shall be no live wiring entering the entire panel.

Live incoming cable terminals are to be located in separate panels to outgoing terminations and are to be effectively shrouded against inadvertent contact.

Equipment shall have adequate current carrying capacity and shall be labelled corresponding to line and schematic diagrams.

An earth bar shall be fitted, to which all non-current carrying metal parts are bonded.

Panels shall not be moved onto site until finishing trade work has been completed in the room where the panels are to be installed. The supplier shall allow in his pricing for storage under suitable conditions until delivery.

**EA11.3 Shop Drawings**

Three copies of shop drawings shall be submitted to the Engineer for approval, two weeks in advance of manufacture.

Shop drawings shall include at least:

- a. Substantiation of the short circuit capabilities of the busbar support system in the form of authority test reports.
- b. Substantiation of the full load rating of the busbars.
- c. Time - current characteristics of the protective devices including, fuses, circuit breakers, and protective relays.
- d. Front and side elevations of equipment and component layout.
- e. Construction, dust proofing, vermin proofing, cable access and cable termination details.
- f. Power single line diagrams drawn to the IEC system.
- g. Control schematic diagrams drawn to the IEC system.
- h. Cable termination diagrams.
- i. Component schedules cross referenced to drawings and equipment.
- j. Component layout drawings showing the position and designation of all components.

**EA11.4 Installation Drawings**

Three copies of installation drawings shall be submitted to the Engineer for approval two weeks in advance of manufacture. The drawings shall include at least:

- a. Adjacent trenches, penetrations, walls, cable trays and other equipment.
- b. Surrounding space available for access and maintenance.
- c. Cable routing and cable entry details.
- d. Details of supports required, other than those built into the control panel.
- e. Details of cable trench covers.
- f. Drawings to be submitted in electronic format Autocad(.dwg).

**EA11.5 Enclosures**

Panels in existing installations shall match existing panels in general appearance.

Sheet steel shall be at least 1.5 mm thick for panels up to 0,75 m<sup>2</sup> and at least 2mm thick for larger panels.

There shall be no lap-welding of the steel frame or steel panels. Burrs, sharp edges, blemishes and welding slag shall be removed prior to painting. Construction shall be dust and vermin proof and suitable for ambient conditions.

Floor standing panels shall be provided with a removable steel channel base.

Panels in excess of 100 kg shall be provided with a removable steel channel base.

Panels in excess of 100 kg shall be provided with removable lifting eyes.

Covers and doors shall be hinged. Lift-out covers will not be accepted.

Panels shall be extensible in both directions.

The finished metal work is to be approved by the Engineer prior to painting.

**EA11.6 Ventilation**

All enclosures shall be ventilated without degrading dust and vermin proofing.

Enclosures containing heat producing equipment shall be louvered such that adequate upward and cross ventilation is obtained.

Ventilation shall ensure that the temperature at any point within the enclosure does not exceed 50°C, irrespective of the ambient temperature, when the equipment is operating at full load.

Outdoor panels shall be fitted with heaters and thermostats to effectively prevent condensation within the panels.

**EA11.7 Vermin Proofing**

Panels shall be protected against the entry of vermin.

Non-hardening compound shall be supplied with the panels to permit sealing of entries after installation of cables.

**EA11.8 Space Requirements**

The panel shall be sized to allow for the following clearances:

- |   |       |
|---|-------|
| a. bare conductors or terminals to earth                  | 45 mm |
| b. insulated busbars to earth                             | 40 mm |
| c. equipment to metal work                                | 50 mm |
| d. vertical distance between horizontal rows of equipment | 75 mm |

When installing equipment in the MCC the equipment shall be install as per the manufactures specifications.

Cable entries and equipment shall be so disposed that the minimum bending radius of cables is not exceeded.

**EA11.9 General and Installation Arrangement Details**

Large circuit breakers and switch fuse units shall be positioned at low level.

Sufficient space shall be allowed between equipment for routing of conductors and expansion of ionised gas.

Flash barriers shall be installed between items of equipment where operation of one item is likely to cause an insulation breakdown in the other.

Control fuses shall be base mounted on busbars. Unprotected wiring may not be run to remote fuses or equipment.

All parts of the control panel metal work shall be electrically continuous and studs shall be provided for earthing the enclosure.

Flexible copper straps shall be used for earthing hinged doors carrying control equipment.

**EA11.10 Cable Gland Plate**

A removable cable gland plate shall be installed across the full width of the panel at a height appropriate to the bending radius of the cables and the manner of approach of the cables.

A channel iron cable support and saddles shall be provided to carry the mass of the cables and

remove mechanical stress from the glands.

#### **EA11.11 Paint Finish**

An electrostatically applied powder coating is the preferred finish. Baked enamel finishes will not be accepted.

Care shall be taken that all edges and corners are properly covered.

Panels shall be electric orange device plates shall be white.

The painting process shall include at least the following steps:

- a. Metal work is to be derusted by complete submersion in phosphoric acid.
- b. Thorough rinsing
- c. Metal work has to have an anti-corrosive coating applied by complete submersion in zinc phosphate followed by thorough rising.
- d. Metal work is to be passivated by submersion in chromic acid
- e. Metal work is to be thoroughly dried
- f. Metal work is to have a 10 micron primer coat applied
- g. Primer coat is to be thoroughly rubbed down with fine abrasive paper and dusted off.
- h. Polyurethane powder is to be applied to a thickness of 100 microns plus or minus 10 microns
- i. The metal work is to be baked at a temperature and for a duration recommended by the supplier of the paint
- j. Painted surfaces are to be cleaned and touched up to the above standard prior to handover.
- k. The contractor shall obtain written approval of the painting process from the paint manufacturer and submit this to the engineer.

#### **EA11.12 Accessories**

Door locks shall be of the Barker Nelson square key type. Hinges shall be of the D hinge type, permitting doors to be lifted off.

Hinges and door locks shall not be welded on.

Hinged doors shall not scratch painted surfaces during repeated opening and closing.

Sealing gaskets shall be of durable non-hardening synthetic rubber and shall be uniformly compressed along the entire length of the gasket without deflecting or buckling panels.

For applications outdoor, bolts, nuts, washers shall be of 316 L stainless steel.

Screws, bolts and nuts must not be in direct contact with paint work.

Self tapping screws shall not be used.

Tapped holes shall have a thread length equal to the diameter of the hole and shall be rust protected by TECTYL.

Busbar bolts shall be of mild steel and shall be fitted with lock nuts and lock washers.

#### **EA11.13 Wiring**

Wiring shall be arranged in horizontal and vertical rows and shall be bound with plastic straps or enclosed in wiring channels. PVC tape shall not be used for bunching or for colour identification.

Bunched conductors shall be uniform and neat and conductors shall enter and leave the harness adjacent to the chassis.

Conductors to hinged doors shall be secured at the door and the frame and the loop between the fixed points shall be covered in a flexible sleeve.

For wiring in trunking the summated cross sectional area of the conductors measured over the insulation shall not exceed 40% of the cross sectional area of the trunking.

Power and control wiring shall not be installed in the same channel.

Holes in metal work shall be fitted with rubber grommets.

Wiring shall not be subjected to pressure points.

Wiring and terminations shall be readily accessible and shall be installed away from terminals or other current carrying parts. Wiring shall not block access to equipment.

Conductors damaged during removal of insulation will be rejected as will insulation stripped beyond the leading edge of terminals.

No joints will be permitted in the run of conductors.

Not more than two conductors shall be connected to a single terminal.

Conductors shall be stranded annealed copper, PVC. Insulated, 600/1000 volt grade to SABS 150.

The minimum conductor size shall be 2,5 mm<sup>2</sup>

Screened cables shall enter panels through compression glands. Conductors shall remain within the screen at terminations for as great a distance as possible and shall leave the cable through the braid without damage to the braid. Screens shall be earthed in the control panel only.

Neutral conductors which are looped between terminals shall have the two ends crimped in a common terminal.

Conductors shall be derated and protected in accordance with the following table. It is to be noted that the maximum temperature within the panel shall not exceed 40°C.

NOMINAL CROSS SECTIONAL AREA (mm <sup>2</sup> )	CONDUCTOR RATING (AMPS)				
	NUMBER OF CONDUCTORS IN BUNCH				
	1				>10
1	13	12	10	9	8
1.5	17	15	14	12	10
2.5	23	21	18	16	14
4	31	28	25	22	19
6	40	36	32	28	24
10	55	50	44	39	33
16	72	65	58	50	43

#### EA11.14 Busbars

Busbars shall be installed along the full length of the control panels and shall be shrouded over that length by an enclosing chamber through which pass only connections to the busbars.

Busbars shall be insulated in heat shrink sleeving and the minimum clearance to earth or between live conductors shall be 40 mm. Breaks to the heat shrink sleeving shall be taped using two layers



of self-adhesive PVC. tape over non-hardening compound.

Busbars and busbar supports shall be electrically and mechanically designed to withstand the dynamic and thermal short circuit stresses occurring at the specified fault level.

Busbars shall be rated for the full load current of the busbar protective device such that the internal temperature of the control panel remains below 40oC.

Busbars shall be of hard drawn, high conductivity copper and shall be of uniform cross section throughout the run.

Tufnol busbar supports may not be used above 10 kA.

Busbar support systems shall have been tested by a recognised authority and a certificate shall be submitted as evidence of the test. The test certificate and support system shall be identified and cross referenced.

Busbar support spacing shall not exceed the spacing used for the test.

#### **EA11.15 Colour Coding**

Busbar phase identification shall be red, white, blue from top to bottom, left to right and front to back when facing the panel.

Conductors shall be identified as follows:-

220/110 volt AC	control Orange
50 volt DC control	Purple (+) and Blue (-).
PLC wiring	Grey
Earth wires	Green/Yellow
Neutral wires	Black
Telemetry wiring	Yellow

#### **EA11.16 Equipment Identification**

All equipment and components used in the control panel shall be identified using the IEC system of identification.

Labels shall be black on white traffolyte and fixed to the panel by bolts and nuts in the close proximity of the component in a position where they may be easily read.

The size of the characters shall be such that they may be read from a distance of 1m by a person with normal eyesight.

#### **EA11.17 Wire Identification**

All wire ends shall be identified using engraved interlocking ferrules which shall be cross referenced to schematic diagrams.

### **EA12 ELECTRICAL INSTALLATION**

This section specifies general requirements of electric equipment and the installation thereof. It is to be read in conjunction with the various Electrical Technical Specifications which have precedence in the event of conflict.

## **EA12.1 Quality Assurance**

### **EA12.1.1 Codes and Standards**

Equipment and methods of installation shall comply with the latest edition and/or amendment of:

- a. Act No. 85 Occupational Health and Safety Act.
- b. SANS 10142-1 Code of Practice for the wiring of premises. LV Installations
- c. SANS 10142-2 Code of Practice for MV Installations
- d. Relevant SANS specifications and codes of practice.
- e. Relevant BSI specifications and codes of practice in the absence of published SANS documents.
- f. Relevant IEC specifications and codes of practice in the absence of published SANS and BSI documents.

Particularly relevant Standard Specifications are as follows:

- IEC 60204-1 Safety of Machinery General
- IEC 60204-11 Safety of Machinery HV below 36kV
- IEC 60298 MV switchgear
- IEC 62271 MV switchgear
- SANS 1029/1030 Mini substations
- SANS 1973 MVC and DB boards
- IEC 60439/60947/61439 MVC and DB boards
- SANS 10198 parts 1-14 MV/LV cable laying

The contractor's attention is drawn to the following requirements:

- The submission of the Health and Safety Plan in accordance with the OHS Act 85.
- Submission of a letter stating that: The contractor has ensured that a person deemed competent in terms of paragraph (b), (c) and (d) of the definition of a competent person in regulation 1 of the General Machinery Regulations, GMR 1521 of 5 August 1988, or a person registered in a professional category in terms of the Engineering Profession Act, 2000, has approved the design, construction and witnessed testing of that part of the installation.
- Any person who erects or installs any article for use at work on or in any premises shall ensure as far as reasonably practical, that nothing about the manner in which it is erected or installed makes it unsafe or creates a risk to health when properly used.

## **EA12.2 Manufacturers**

If they comply with these specifications and requirements, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

## **EA12.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local

office must carry sufficient stock and spare parts for the project.

#### **EA12.4 Submittals**

Shop drawing submittals shall include, but not be limited to, the following:

- a. The Contractor shall submit to the Engineer for review, a list of the proposed manufacturers of cables, cable lugs, cable connectors, and termination fittings listed herein. The Contractor may install cable, cable lugs, cable connectors, joints and termination fittings furnished by any manufacturer listed on the approved submittal.
- b. Cut sheets on all conductors with manufacturers name, ratings and capacities, insulation characteristics, and available colours, clearly listed.
- c. Cut sheets indicating all cable lugs, termination fittings, joints and cable connectors.
- d. Cut sheets indicating types of conductor identification bands.
- e. Additional information as required in the specification.

#### **EA12.5 Cable Installation**

##### **EA12.5.1 Excavations and Trenching**

###### **A. General**

The purpose of this specification is to ensure standards are maintained for the installation and backfilling of electrical cables on this project, it is essential to ensure that any possible subsidence of cable trench backfilling is eliminated.

The electrical contractor may be required to excavate, in all kinds of ground and to an appropriate depth and width, trenches for the installation of cables and/or the installation of cable ducts. All excavations shall comply with the requirements of the OHS Act as well as local bylaws and regulations.

The electrical contractor shall take all the necessary precautions and provide the necessary warning signs, red and white plastic chevron tape (danger tape) and/or lights to ensure that the public and/or employees on site are not endangered.

The electrical contractor shall ensure that the excavations will not endanger existing structures, roads, railways, other site construction, or other property.

The electrical contractor shall be responsible for the provision of all planking, shoring, strutting, temporary bridging, roping, warning lamps and notices well as other precautions to prevent danger to persons.

The engineer may instruct the electrical contractor to install additional safeguards, at his own expense, but this shall in no way relieve the electrical contractor of his responsibility to ensure safety of the excavations.

Although not bound in or issued with this document (specification), the following Standard

Specifications shall form part of the contract documents. The Contractor shall be in possession of these Standard Specifications and their related Codes of Practice which apply equally and shall keep copies thereof on site for reference by himself or the Engineer for the duration of the Contract.

- SANS 1200 DB-1989: Earthworks (Pipe Trenches).
- SANS 0198 Selection, Handling & Installation of Electric Power Cables.

**B. Liaison**

The electrical contractor will be required to liaise with the Engineer in Charge to co-ordinate the installation of all services, it is a requirement of this contract that close liaison be maintained at all times in order to eliminate or at least minimise any misunderstandings.

**C. Routes**

The electrical contractor shall familiarise himself with the routes and site conditions and shall then plan the procedure and order of doing the work in conjunction with the general construction programme for other services and construction requirements. All cable routes have been carefully planned and must be marked out on site, measured and pegged by a competent person appointed by the electrical contractor.

Electrical cable trenches are to be co-ordinated with other known underground services. Cables shall be run parallel or at right angles to roads and building structures. Diagonal routes shall be avoided. The Engineer shall approve any major route deviations due to obstructions of existing services before the excavation being undertaken.

The Engineer reserves the right to alter any cable route or portion thereof in advance of installation of cable. Payment in respect of any additional or wasted work involved shall be at the documented rates. The electrical contractor shall allow for the removal of obstructions along the cable routes including all tree roots and similar obstructions.

**D. Existing Services**

The electrical contractor shall obtain from the employer, engineer or the relevant Local Authority full details of existing buried services along the route and shall ensure that this information is passed to the individual directly responsible for the excavation. The electrical contractor shall be responsible for ensuring that all due care is taken when excavating near such existing services. Only labourers with experience of these conditions may be utilised.

The electrical contractor will be required to prove any existing or new services in the vicinity of his trenches by careful hand excavations to avoid unnecessary disruption of supply to consumers or avoid damage to new services. All services must be successfully proved prior to excavation of trenches commencing in an area. Under no circumstances will the use of mechanical equipment/excavator be permitted to locate any of the services. Mechanical excavators shall not be used within one metre of any known existing services nor shall they be used in other open ground without the prior written permission of the engineer.

If any damage is caused by the electrical contractor's staff to existing buried services, the electrical Contractor shall immediately notify the engineer to that effect and shall take such temporary or permanent remedial measures as the engineer may direct. All such measures shall be effected at the electrical contractor's expense.

**E. Mechanical Excavators**

Power-driven mechanical excavators may be used for trenching operations if 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 electrical contractor is advised that a major portion of the excavation shall be undertaken in the roadways with a major vehicular traffic and the mechanical excavator shall not cause any traffic congestion. The use of power-driven mechanical excavators shall be subject to the approval of the engineer.

**F. Blasting**

No guarantee is given or implied that blasting will not be required. Should blasting be necessary and approved by the engineer, the electrical contractor shall obtain the necessary authority from

the relevant government department and local authorities. The electrical contractor shall take full responsibility and observe all conditions and regulations set forth by the above authorities.

G. Shoring & Water Pumping

The Electrical contractor shall provide shoring for use in locations where there is a danger of the sides of the trench collapsing due to water logging or other ground conditions, to the full requirements of the OHS Act.

The strength of shoring must be adequate for site conditions prevailing and the shoring must be braced across the trench. The Electrical contractor shall provide all pump and equipment required to remove accumulated water from trenches. Water or any other liquid removed shall be disposed of without any nuisance or hazard. High water tables may be encountered.

H. Trenching

Trenching shall be programmed in advance and the approved programme shall not be departed from except with the consent of the 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 that may cause tensile forces in the cable during back filling. 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 back filling on completion of the cable installation.

Surplus material shall be removed from site and disposed of at the cost of the electrical contractor. Trenches across roads access ways or footpaths shall not be left open. If cables cannot be laid immediately the electrical contractor shall install temporary "bridges" or cover plates of sufficient strength to accommodate the traffic concerned.

Before cable installation the trench shall be inspected thoroughly and all objects likely to cause damage to the cables during or after cable installation 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 Engineer shall be notified before installing the cables. The 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, a person qualified to do so shall replace them.

I. Dimension of Trenches

All cable trenches are to be sized to suit specific cable requirements in accordance SANS 10198. The engineer will determine any other combinations of cable installation on site and site instructions issued to the electrical contractor accordingly. The final ground levels must be confirmed with the engineer in charge by the Contractor.

Cable trenches for one or two cables shall not be less than 400 mm wide and need not be more than 700 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 spacing stipulated. Where trenches change direction or when cable slack is to be accommodated, the electrical 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 installation depths and bedding thickness. Where the bottom of the trench has been loosened during excavation, it shall be compacted at OMC to 95 % MASSHTO density prior to laying of cable/s and bedding. Where the bottom of the trench has been excavated to a depth greater than that specified or ordered, the electrical contractor shall at his own expense replace the excess material so removed with fine granular material compacted to 95 % MAASHTO density or with 10 MPa concrete, as directed by the engineer.

- For MV cables only, trenches shall be 1100 mm deep with bedding of 100 mm deep below the cable (cable 1000mm deep) and 150mm bedding above the cable. The MV cable protection slab shall be placed 200mm above the MV cable.
- For armoured fibre optic cables laid in the ground, cables may be laid in the same trench as the power cables but must be spaced apart from the power cables encased with bedding as described below. A plastic danger tape "fibre-optic cable" shall be placed above the cable 350mm below normal ground line.

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

J. Bedding

Before installing the cables, all injurious items shall be removed from the bottom of the trench. The engineer shall inspect the floor of the trench before it is evenly covered with a layer of compacted sifted backfill or fine soil to a level that is at least 100 mm above the highest unevenness of the trench.

Only sandy clay or loam soil with a satisfactory thermal resistivity (not exceeding  $1,5^{\circ}\text{Cm/W}$ ) may be used for this purpose. The soil shall not contain any stones or lumps larger than 13.2 mm. 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 electrical 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 installation a further layer of bedding shall be provided to extend to 150 mm above the cables.

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

K. Back Filling

The Electrical contractor shall not commence with the back filling of trenches without prior notification to the Engineer so that the cable installation may be inspected. Should the Electrical contractor fail to give a timeous notification, the trenches shall be re-opened at the Electrical contractor's cost. Such an inspection/survey will not be unreasonably delayed. Back filling shall be undertaken with soil suitable to ensure settling without voids. The maximum allowable diameter of stones present in the backfill material is 26 mm and all large or sharp stones or other debris shall be removed from the fill material.

The electrical contractor shall have allowed in his tender for the removal of surplus material and the importation of suitable backfill material if required.

Back filling of trenches may commence after the trenches have been approved and the position of all cables recorded and dimensioned on the as-built construction drawings. All trenches shall be backfilled in layers of thickness (after compaction) not exceeding 150 mm and the material

shall be compacted to 93 % of modified AASHTO maximum density in the case of cohesive soil or 98 % in the case of non-cohesive soil. Care shall be taken to ensure newly laid cable is not damaged during compaction of trenches. Mechanical compactors shall be used, hand compaction will not be accepted.

The electrical contractor shall appoint independent experts to perform compaction tests for the compaction and provide a report to confirm that the compaction complies with the above specification.

Where trenches are in grassed or open areas sufficient allowance must be made for final settlement.

For the first layer of 150 mm, sifted soil of which 75 mm must be below and 150 mm must be above the cable, must be used. Where no suitable soil is available on site, the Electrical contractor shall import fill from elsewhere and make all the necessary arrangements to do so.

L. Surplus Ground

All surplus ground and rocks shall be removed from the works and dumped at a site to be approved by the Engineer. The cost of this work shall be included in the Electrical contractor's price for excavation of trenches etc.

M. Cable Work

All MV and LV cables must be installed in accordance with SANS 10198 and the Electrical contractor must adhere to the minimum bending radii specified. The storage, transportation, handling and installation of all underground cables shall be according to first class practice, and the electrical contractor shall have adequate equipment and labour to ensure that no damage is done to the cables during such operations. The final ground levels must be confirmed with the engineer or employer before cables are installed.

Regarding the installation of low voltage cable, the following requirements shall be complied with:

- Under no circumstances should a drum or reel of cable be dropped during unloading or transport to or on a site. When rolled, drums and reels must always be rolled in the direction of the arrow marked upon the flange. The protective cover and securing tie of the inner end must be removed before the cable is unwound. It is essential that cables should be installed only when both the cable and the ambient temperature are above 10°C.
- The cable shall be removed from the drum in the direction indicated in such a way that no twisting, tension or other mechanical damage is caused, and must be adequately supported at short intervals during the whole operation.
- Particular care must be exercised where it is necessary to draw cables through pipes and ducts to avoid abrasion, elongation, or distortion of any kind. Multiple cables may be drawn through a single sleeve pipe provided sufficient air space is allowed and the heat and current capacity of the cables are not adversely affected.
- Suitable approved cable rollers onto which the cable shall be drawn must be placed in or alongside the cable trench. The rollers must preferably be spaced two metres apart, but the spacing must under no circumstances exceed three metres.
- The maximum speed at which cables shall be drawn must not exceed 10 metres per minute.
- The cable must be bent slowly and carefully and the minimum radius of curvature must not be less than "12 d" where "d" is the overall diameter of the cable.

- Where cables are cut and not immediately made off, the ends are to be adequately sealed immediately.
- The electrical contractor is advised to measure actual lengths of cable required on site before ordering as he will not be compensated for redundant cable or in fact any other material over supplied. Optimum use shall be made of cable to avoid cable joints in cable.
- The separation between cables of the same voltage shall not less than 150mm.
- Cables installed within the inspection access in which the distribution board is installed shall be saddled to the concrete with stainless steel saddles and stainless steel fixings.

N. Cable Slack

At every termination, sufficient slack shall be provided for future repairs to the cable end should this become necessary due to a fault or some unforeseen circumstances on site.

O. Cable Identification

Every power distribution cable, switchboard interconnecting cable, and any other cable, shall be provided at both ends of the run with an approved Bowthorpe Hellerman tag showing the size and details of the cable. All identifications shall correspond with the construction record drawings and single-line diagrams associated with the contract.

P. Cable Joints and Terminations

MV cable joints and terminations may only be carried out by an accredited cable jointer who has passed the MV paper cable jointing course run by the eThekweni Municipality. All MV accessories shall comply with the requirements of NRS 053. MV cable joints will only be permitted in cable drum lengths exceeding 300 metres or where a new length of cable needs to be spliced into an existing cable.

MV cable joints shall be of the heat shrink, filled type provided with a core separator and filler mastic of make approved by the EThekweni Municipality Electricity Department. Three phase cable joints shall be designed to permit the crossing of cores in the joint, however cables should be laid in a manner to avoid the cores from crossing each other. The use of "Tyco" mechanical connectors using shear head bolts for joining the copper conductors will be acceptable. Connectors shall incorporate an oil block. The heat shrink material used shall have a minimum wall thickness of at least 1.0 mm after application. The main earthing conductor of the joint shall be connected to the lead sheath of the cable by a constant force spring. A layer of tinned copper shall be provided for application under the constant force spring (CFS) and connected to the armouring of the cable with a CFS. The CFS shall have a minimum width of 20 mm and shall be suitable for the cable width. The MV cable joint shall be prepared on a concrete base to maintain the stability of the joint on a level plain and the slab above the joint shall indicate "Cable Joint" Both the indoor (for mini-sub) and the outdoor (for the overhead line connection) MV cable terminations shall be of the type utilising heat shrink sleeving to the approval of the EThekweni Municipality.

The mini-sub cable terminations shall be classified as indoor terminations for use in air filled enclosures. Clearances within the enclosure shall be in accordance with NRS 012. Right angle connections shall be fitted with an insulated right angle boot.

Unless otherwise specified indoor cable termination tails shall have a length of 650mm and outdoor termination tails a length of 1600mm for 11kv cables. The specific creepage for both indoor and outdoor terminations shall be at least 31mm/kv. A semi-conductive tube shall be provided that covers the metallic-paper core screen from the break-out boot to the end of the core screen. The purpose of the conductive tube is to prevent the metallic-paper core screen



from moving during the termination process. Heat shrink sleeving must cover the barrel of the connecting lug. Outdoor terminations shall be provided with crutch support to prevent damage to the cable crutch and core insulation from over tri-furcating and shall be fitted with rain skirts.

Joints in LV cable runs shall not be allowed unless specified or authorised in writing by the engineer.

All joints in LV cables shall be made either by means of compound filled boxes according to the best established practice by competent cable jointers using first class materials or by means of approved epoxy-resin pressure type jointing kits such as "Scotchcast". Epoxy resin joints must be made entirely in accordance with the manufacturer's instructions and with materials stipulated in such instructions. The electrical contractor will issue the engineer with a copy of the jointing instructions associated with each type of termination or straight through joint, being installed on site.

Low voltage PVC cables are to be made off with sealing glands and materials designed for this purpose which must be of an approved make. Where cables are cut and not immediately made off, the ends are to be sealed immediately.

Q. LV Cable Glands

All cable glands shall be rated at IP 65 with corrosion guard and shall conform to SANS 1213. Type: Pratley, CCG or equal and approved.

R. Cable Tests

All equipment required to carry out MV and LV tests on cables and switchgear shall be provided by the contractor. All MV cable and switchgear tests must be witnessed by the engineer and recorded by the contractor.

Where cabling has been installed in the form a ring main, the contractor shall ensure by testing that there is no cross-over of phases which would result in a phase to phase fault in the event of the ring being operated in the closed position. Phase to phase sticks will be required for this test. Phase to phase tests shall be proved by the contractor before closing the 11kv ring.

All MV paper cable and accessories shall be tested in accordance with IEC 6005-1 table 3. AC pressure test equipment will be required for this purpose.

Each section of laid and jointed LV cable shall be tested in accordance with SANS 1507. The insulation resistance shall be measured with a 1000-volt insulation tester and the readings shall be tabulated and certified. Similarly, the earth continuity resistance of each section of cable shall be measured and recorded. All low voltage cables must be tested on site before final terminations after installation of cable glands, in the presence of engineer. All test results must be submitted to the engineer.

Tests on completion of the installation and jointing of the various cables shall be carried out on site in the presence of the engineer and the test results properly recorded and submitted in triplicate.

On each completed section of laid and jointed cable, the insulation resistance shall be tested in accordance with specification for testing included elsewhere in this document.

The cables must be adequately supported at intervals during the whole operation.

Particular care must be exercised where it is necessary to draw cables through pipes and ducts to avoid abrasion, elongation or distortion of any kind. The ends of such pipes and ducts shall be sealed to approval after drawing in of the cables.

**S. Cable Sleeves**

Sleeves which are not currently installed will be installed by the electrical contractor. It shall be the responsibility of the electrical contractor to ensure that all the sleeves are correctly installed. All electrical sleeves across roads and paved areas will be uPVC150mm nom. diameter.

Before backfilling each end of all sleeves entering buildings or substations shall be sealed with Pratliperl™ to prevent ingress of vermin and prevent the cable sleeve from acting as a storm water or ground water drainage system.

**EA12.6 Cable Ladder**

Cable ladders, trays, hangers and fixings shall be of 3CR12 in both indoor and outdoor applications. Cable ladders, fittings and fixtures shall be the product of one manufacture.

Purpose made bends, tees, offsets and the like shall be used in preference to site manufacture.

Cable ladders shall be earthed at a point closest to the source of supply and continuity shall be maintained across joints by means of jumpers. The minimum size of the earth continuity conductor shall be 16 mm<sup>2</sup>, the bonding conductor shall be 10 mm<sup>2</sup> and it shall be green PVC insulated.

Cable ladders shall be run horizontally or vertically within tolerances that can be detected on a 1 metre spirit level.

**EA13 VARIABLE FREQUENCY DRIVES**

This document shall be used to specify the required features of VFDs that are designed for use with standard IEC and/or NEMA AC induction motors, synchronous reluctance motors (SynRM) and permanent magnet motors (PM) in Water and Wastewater applications.

Any deviations from this specification must be:

A) LISTED and

B) APPROVED

by the specifier PRIOR to the quotation.

**EA13.1 General****EA13.1.1 Description**

This specification is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with a standard AC induction motor, synchronous reluctance (SynRM) and permanent magnet (PM) motors in Water and Wastewater applications.

The VFD manufacturer shall supply the VFD and all necessary options as specified. VFDs that are manufactured by a third party and "brand labeled" shall not be acceptable. All VFDs installed on this project shall be from the same manufacturer.

**EA13.1.2 Terminology Used**

This specification is to cover a complete Variable Frequency Drive (VFD) consisting of a pulse width modulated (PWM) inverter designed for use with a standard AC induction motor, synchronous reluctance (SynRM) and permanent magnet (PM) motors in Water and Wastewater applications.

a. Cabinet: Enclosure into which the VFD may be built

- b. Control panel: Device to be used in controlling and/or monitoring the VFD; normally attached on the VFD cover or on the cabinet door
- c. Motor: Induction motor (IM), Permanent magnet Motor (PM) or Synchronous reluctance motor (SynRM), typically IE2, IE3 or IE4 efficiency class
- d. THDi: Total Harmonic Distortion of current
- e. VFD: Variable Frequency Drive (aka: AFD, ASD, VSD, inverter, drive, etc)

#### EA13.1.3 Quality Assurance

##### A. Referenced Standards and Guidelines:

- a. International Building Code (IBC)
  - IBC 2012 Seismic – referencing ASC 7-05 and ICC AC-156
- b. International Electro-technical Commission (IEC)
  - IEC/EN 61800-3, Adjustable speed electrical power drive systems
  - IEC/EN 60529:1992 + A2: 2013 (IP), Degrees of protection provided by enclosures
  - IEC 60664-1:2007, Insulation coordination for equipment within low voltage systems
  - 2014/35/EU Low voltage directive
  - 2014/30/EU Electromagnetic compatibility (EMC)
  - 2006/42/EC Machinery directive
- c. Institute of Electrical and Electronic Engineers (IEEE)
  - IEEE 519, Guide for harmonic content and control
- d. International Organization for Standardization (ISO)
  - ISO 9001:2015, Quality Management System
  - ISO 14001:2015, Environmental Management System
  - ISO 45001:2018, OHSMS Management System
- e. National Electric Code (NEC)
  - NEC 430.120, Adjustable-Speed Drive Systems
- f. National Electrical Manufacturer's Association (NEMA)
  - ICS 7.0, AC Adjustable Speed Drives
  - NEMA 250:2008, Enclosures for Electrical Equipment
- g. Underwriters Laboratories (UL)
  - UL508A, Industrial control panels
  - UL508C, Power conversion equipment
  - UL61800-5-1, Standard for adjustable speed electrical power drive systems

##### B. Qualifications:

- a. The VFD manufacturer shall:
  - have a minimum of 40 years of experience in VFD design and manufacturing and have adequate business volume in order to provide credibility in its commitments and capability for long-term support,
  - be able to make identical products in more than one location, in order to ensure production capacity at all times,
  - have a Functional Safety Management system and valid IEC 61508-1 certificate available,

- have a valid ISO 9001:2008 certification and an applicable quality assurance system and certificate available,
  - have a valid Environment Certification ISO 14001:2014 and certificate available,
  - have an Occupational Health and Safety Management system and valid OHSAS 45001 certificate available.
- b. The VFD shall comply with the technical requirements specified in IEC/EN 61800-5-1:2007 (Adjustable speed electrical power drive systems – Part 5-1: Safety requirements – Electrical, thermal and energy).
- c. The VFD shall with the technical requirements specified in EN 61800-3:2004 + A1:2012 (Adjustable speed electrical power drive systems – Part 3: EMC requirements and specific test methods).
- d. CE mark - The VFD shall comply with the following directives, required for the CE mark:
- Low Voltage Directive 2014/35/EU of the European Parliament and of the Council of the European Union.
    - The VFD shall have the manufacturers name and postal address printed on the VFDs type label and package label according to LVD 2014/35/EU.
    - The contact details shall be clearly printed and not removable from the VFD.
  - VFDs without the manufacturer's name and contact details are not acceptable.
  - Electromagnetic compatibility (EMC) Directive 2014/30/EU of the European Parliament and of the Council of the European Union.
  - Machinery Directive 2006/42/EC of the European Parliament and of the Council of the European Union.

A manufacturer's Declaration of Conformity to confirm compliance with mandatory directives shall be available for public access. The Declaration of Conformity of Machinery Directive shall specify the person authorized to compile the VFDs technical file for safety functions. Contact details shall be included in the Manufacturers Declarations.

- e. cULus approval
- The VFD shall comply with the technical requirements of UL according to UL61800-5-1. A UL listing document shall be available to confirm VFDs compliance with the requirements.
  - In lieu of UL61800-5-1 compliance, the VFD shall comply with the technical requirements of UL according to UL508C. A UL listing document shall be available to confirm VFDs compliance with the requirements.
  - Along with the declaration, there shall be the UL (Underwriters Laboratories) mark on the VFDs type label to identify the compliance.
  - Pending UL approval is not accepted.
  - The VFD shall be UL labeled 100 kA SCCR, RMS Symmetrical, 600V max.
- f. Environmental Manufacturing
- The VFD shall comply with Restriction of Hazardous Substances in Electrical and Electronic Equipment directive 2011/65/EU requirements, so called RoHS II requirements.
  - The VFD shall be easy to recycle. The manufacturer shall make recycling instructions publicly available. The recycling instructions shall provide recycling information in accordance to Waste Electrical and Electronic Equipment directive 2012/19/EU (WEEE).
  - The VFD shall not contain toxic or hazardous substances or elements above the maximum concentration values as specified in the People's Republic Electronic

Industry Standard (SJ/T 11364-2014). The EIP (Electronic Information Products) mark shall be on the VFDs type label to identify EIP compliance.

g. Functional Safety

- The VFDs shall support 'Safe Torque Off' (STO) function capable for safety related applications up to SIL 3, SILCL 3 and PL e.
- The VFD shall comply with the following standards
  - IEC 61508:2010; SIL
  - ISO 13849-1:2006; PL e
  - IEC 62061:2005; SILCL 3
  - IEC 61800-5-2:2007; SIL 3
- There shall be a 3rd party statement of compliance available to confirm the VFDs compliance. Manufacturer's statements are not accepted to confirm compliance

EA13.1.4 Submittals

The Submittals shall include the following information:

- Product Overview
- Dimensional Drawings
- Control Circuit Drawings
- Engineering Data including rating tables and weight
- General Notes

**EA13.2 Variable Frequency Drives (VFD)**

EA13.2.1 General

- A. The VFD must be designed specifically for the Water and Wastewater market. General purpose products are not acceptable.
- B. The VFD shall have the same customer interface, including control panel, I/O connections and firmware, regardless of power, voltage rating or harmonic mitigation solution.
- C. The VFD shall be solid state, with a Pulse Width Modulated (PWM) output. The VFD shall be a Sensorless Vector AC to AC converter utilizing the latest Insulated Gate Bipolar Transistor (IGBT) technology. The VFD shall employ a Sensorless Vector inner loop torque control strategy that mathematically determines motor torque and flux. The VFD must also provide an optional operational mode for V/Hz operation.
- D. Electrical network
  - a. The VFD shall be rated to operate from:
    - 3-phase, 380 to 480 VAC, +10%...-15%
  - b. The VFD shall operate with supply frequencies from a minimum range of 47.5 to 63Hz. Nominal power ratings shall be met in the allowed frequency range.
  - c. The VFD shall operate should a minimum +/- 3% of nominal phase to phase input voltage imbalance exist. Nominal power ratings shall be met at all times.
  - d. The VFD shall be allowed to be used on TN (grounded), IT (ungrounded) and corner grounded TN systems without options or hardware modifications.
  - e. The VFD shall employ a full wave rectifier to prevent input line notching and operate at a fundamental (displacement) input power factor of 0.98 at all speeds and nominal load.

- f. The VFD shall be designed to be used in, and to meet the requirements of, public low voltage networks. VFDs designed only for industrial electrical networks are not accepted.
- g. The VFD must comply with SEMI F47 – the semiconductor industry standard for voltage sag immunity. Compliance shall be verified by a third party.

E. EMC, Electromagnetic compatibility

- a. The VFD shall have inbuilt EMC/RFI filters as standard.
  - It shall be possible to disconnect the EMC filters without specific tools (for IT and corner grounded TN electrical systems).
- b. The VFD shall conform to the European Union Electro Magnetic Compatibility (EMC) Directive EMC 2014/30/EU, a requirement for CE marking.
- c. The VFD shall comply with the EMC Product Standard for drives EN 61800-3 Class C3 (2nd environment, restricted distribution) as standard.
- d. The manufacturer shall provide suitable cable glands for EMC compliant installation.

F. Harmonics

- a. The VFD shall comply with mandatory Equipment Standard IEC/EN 61000-3-12:2007: Limits for harmonic currents produced by equipment connected to public low voltage systems.
- b. The manufacturer shall provide a tool for calculating the current and voltage harmonics at the input terminals of the VFD.
- c. The VFD shall not contribute any significant harmonics at the input terminals of the VFD and shall maintain harmonics levels at the VFDs input terminals to levels at or below those listed in "Harmonic Control in Electrical Power Systems, IEE Std. 519-1992" in the system that is already in compliance with the said standard.
- d. The input current to the VFD shall have a total harmonic content less than 5% of full rated capability at the input terminals of the VFD on a power system sized according to IEEE 519-1992 at a line voltage unbalance up to 3% and under all motor load conditions.
- e. The VFD design shall not compensate for existing harmonic content in the distribution system.
- f. The VFD harmonic solution shall be contained within the VFD, not require external hardware (ie transformers, filters, etc) and not require additional wiring (ie 3 power wires in, 3 motor wires out).
- g. Regenerative front end VFDs used as harmonic solutions are not acceptable, due to possible regeneration on to power distribution network. The VFD shall not interfere with the Emergency Back-up Generator's voltage regulator.
- h. VFD without DC Bus capacitors are not acceptable.

G. Environmental conditions

- a. Temperature
  - The VFD shall have a minimum temperature range for transportation and storage from -40 to 70 °C.
  - The VFD shall operate without disturbances in continuous ambient temperatures with a minimum range from -15 to 50 °C (no frost allowed).
- b. Altitude
  - The VFD shall be suitable for safe operation up to a minimum of 4000 m (13,000 ft) altitude in neutral grounded TN electrical systems.
  - The VFD shall be suitable for safe operation up to a minimum of 2000 m (6,500 ft) altitude in corner grounded TN electrical systems or IT systems.
- c. Humidity

- The VFD shall be designed to operate in ambient conditions of relative humidity with a minimum range from 5 to 95% (without condensation).
  - A motor heater function shall be supported to prevent condensation and corrosion of the motor.
- d. Vibration
- The VFD shall be designed to operate in vibrating environments with vibration limits allowed per IEC 60068-2 (modules) or IEC 60721-3-3 (cabinets).
- e. Contamination
- The VFD shall operate in contamination levels according to IEC 60721-3-1, IEC 60721-3-2 and IEC 60721-3-3; Chemical gases min. class 3C2, Solid particles class 3S2.
  - All printed circuit boards (PCB) shall be conformal coated to extend the electronics lifetime in harsher environments.
- H. The protection class of the VFD (class defined by IEC/EN 60529:1989 + A1:1999 + A2:2013) shall not reduce the output current rating nor any environmental condition ranges.
- I. The VFD output frequency shall be adjustable between 0 to 500Hz, forward or reversing. Operation above motor nameplate shall require programming changes to prevent inadvertent high-speed operation.
- J. Maintenance
- a. The VFD shall have cooling fans that are designed for easy replacement. The fans shall be designed for replacement without removing the VFD from the wall or removal of circuit boards.
  - b. The VFDs main cooling fans for the power electronics shall be speed controlled based on the cooling need. Fan speed should be controlled to extend the fan and fan bearing operating lifetime.
  - c. The VFD shall record a) VFD on-time, b) VFD run-time and c) cooling fan on-time for maintenance logging purposes.
  - d. The VFDs cooling fans shall have a minimum expected lifetime of 6 years.
  - e. Any battery used in the VFD shall have a minimum expected lifetime of 6 years.

For cabinet-built VFDs, all heavy components shall have a service position for safe maintenance operation.

#### EA13.2.2 Motor Control

- A. The VFD shall be capable of controlling an induction motor, permanent magnet motor and synchronous reluctance motors as standard.
- B. It shall be possible to commission an induction motor, permanent magnet motor and synchronous reluctance motor with the motor nameplate values only, without the need to get the motor values from other sources.
- C. The VFD shall include scalar and vector control modes with independent control chains and parameters for each control mode.
- D. The overload rating of the VFD shall be 110 % of its rated normal duty current for 1 minute every 10 minutes and with a minimum of 130 % for 2 seconds every 1 minute. Overload ability shall be available at all times - not only at start.
- E. The VFD shall be capable of sensing the loss of load (broken belt / broken coupling / dry pump) and signal the loss of load condition. The VFD shall be possible to be programmed to signal this condition via a control panel warning, relay output and/or over the serial communications.

- a. Relay outputs shall include programmable time delays that will allow for VFD acceleration from zero speed without signaling a false underload condition. Underload and overload curves shall be user-definable.
- F. It shall be possible to disconnect a motor running full speed by opening an optional contactor between motor and VFD without causing any damage to the VFD.
- G. The VFD shall include a standard embedded functional safety feature Safe Torque Off, (STO), to make the motor mechanically safe.
- H. The VFD shall include an energy optimization circuit (flux optimization) that will automatically reduce applied motor voltage to the motor to reduce energy consumption by up to 10% and lower audible motor noise.
- I. The VFD shall be capable of starting into a spinning load (forward or reverse) up to full speed and accelerate or decelerate to a set-point (flying start) without tripping or component damage.
- J. The VFD shall restart after a power loss without the need to resend the start command. This feature shall be there regardless of the control source, control panel, I/O or fieldbus.
- K. Flux braking shall be available, where the VFD controls the motor to dissipate the extra rotary energy as heat whenever braking is required. It shall be possible to use this flux braking feature to decelerate the motor from one speed to another – not only for stopping the motor.
- L. Power Loss Ride-Through shall be programmable. If the incoming supply voltage is cut off, the VFD continues to operate using the kinetic energy of the rotating motor. The VFD continues to be operational as long as the motor rotates and generates energy.
- M. The VFD shall include a switching frequency control function. This adjusts the switching or carrier frequency, based on actual VFD temperature and allows the highest carrier frequency without de-rating the VFD or operating at high carrier frequency only at low speeds (temperature fold-back). It shall be possible to set a minimum and a reference switching frequency.
- N. The VFD shall include a noise smoothing function, which distributes the acoustic motor noise over a range of frequencies instead of a single tonal frequency resulting in lower peak noise intensity.
- O. The VFD shall have three programmable critical frequency or critical speed lockout ranges to prevent the VFD from operating the load continuously on an undesirable speed range (skip frequencies)

#### EA13.2.3 Standard Control Hardware Features – Adjustable by the User

##### A. General I/O

- a. All I/O terminals shall be color coded to simplify wiring and troubleshooting.
- b. All I/O shall be accessible (monitor and control) for fieldbus protocols (pass-through I/O).
- c. It shall be possible to monitor status of the I/O from the control panel.
- d. The VFD shall have a special mode for testing the I/O and VFD configuration without requiring external equipment connected.

##### B. Analog I/O

- a. The VFD shall have at least two programmable analog inputs. Both inputs shall accept current (0 to 20 mA or 4 to 20mA) or voltage (0 to 10 VDC) signals. The signal type selection, current or voltage, shall be made via the VFD user interface; DIP-switches or jumpers are not allowed.
- b. The analog inputs shall be freely programmable to be used e.g. as speed reference, frequency reference, pressure monitor or PID loop controller's setpoint reference or feedback signal.
- c. The VFD shall have at least two programmable analog outputs (0 to 20 mA or 4 to 20 mA); out of which one shall be configurable to be either a current or voltage (0 to 10 VDC). The signal type selection, current or voltage, shall be made via the VFD user interface; DIP-switches or jumpers are not allowed.



- d. The analog outputs shall be freely programmable to give an output signal proportional to any data available via the VFD user interface (including, but not limited to: frequency, motor speed, output voltage, output current, motor torque, motor power, DC bus voltage, active reference and other data).
- e. Analog I/O signals shall have an accuracy of > 99% of full scale in both current and voltage modes.
- f. If the input reference (4 to 20 mA or 2 to 10 VDC) is lost, The VFD shall give the user the option of: (1) stopping and displaying a fault; (2) running at a programmable preset speed and displaying an alarm; (3) hold the VFD speed based on the last good reference received and displaying an alarm. It shall be possible to program the VFD to signal this condition via the control panel, relay output and/or over the serial communication bus.

#### C. Digital I/O

- a. The VFD shall have at least six programmable digital inputs (24 VAC and 12 to 24 VDC, PNP or 5 pcs NPN) to connect to external devices, as follows:
  - All inputs can be configurable for PTC sensors.
  - There shall be a programmable run permissive circuit.
  - Up to four programmable free text interlock inputs shall be available.
  - The VFD shall have at least one digital input which can be configured to receive a pulse signal up to 16 kHz.

#### D. Relay I/O

- a. The VFD shall have at least three programmable digital Form-C relay (changeover) outputs. The relays shall include programmable on and off delay times.

#### E. I/O Optional Extension Modules

- a. The following I/O option modules shall be available:
  - A module with two relay outputs and one digital output.
  - A reinforced insulated PTC input module for up to six PTC sensors with the capability to trigger the STO circuitry of the VFD.
  - A module to provide an additional six digital inputs which can be operated with 115 VAC or 230 VAC voltage.

An ATEX (EU directive 2014/34/EU) certified Ex II (2) GD PTC input module for up to 6 PTC sensors with the capability to trigger the STO circuitry of the VFD

### EA13.2.4 Software Features

#### A. Water specific features:

- a. The VFD shall have specific pump control functionality to control up to six pumps with one VFD to allow distribution of pump usage in a multiple pump system.
- b. The VFD shall have multipump functionality with an intelligent master/follower configuration for controlling up to eight parallel pumps equipped with own VFD without additional devices:
  - The VFD shall have a parameter synchronization feature to broadcast PID, Multipump and Analog Input parameters to ensure system parametrization is equal in the parallel VFDs
  - The VFD shall have specific functionality to start and stop the pumps based on the required pumping capacity. In order to balance the operating time of the pumps, the

- VFD shall have the capability to change the order in which the pumps are started and stopped.
- The VFD shall have the capability to give priorities for parallel pumps in the system to enable the most efficient pumps to be operated the most.
  - The VFD shall have the capability to set a maximum stationary time to ensure all pumps get exercised regularly, regardless of their priorities.
  - The VFD shall have the capability to control across-the-line pumps instead of parallel VFDs, in order to resolve the system demand.
- c. The VFD shall have a level control function with operation modes for optimal tank filling or emptying supporting up to eight parallel pumps.
- User-programmable start level shall indicate the point at which the pump will start.
  - The pump(s) shall operate in user-programmable “efficient speed”.
  - If the level keeps raising, more pumps will be started based on unique start levels.
  - There shall be a possibility to connect high- and low-level limit switches, which will trigger either full speed pumping or pump stop, depending if the application is for filling or emptying a tank
- d. The VFD shall have the ability to calculate the flow based on the measured pressure difference (using pressure sensors) or the power curve of the pump (sensorless).
- There shall be a multiplier parameter to enable correction for the calculation.
  - There shall be a specific energy parameter to measure actual flow per input power ratio. The motor speed can be adjusted to locate the most economical pumping point.
- e. The VFD shall have two additional ramps for quick acceleration and two additional for deceleration in order to reduce wear of the mechanical parts in submersible pumps.
- f. The VFD shall have soft pipe filling function with flexible user parameter settings to protect the system. There shall be a configurable pipe fill time to ensure the setpoint is reached within a desired time.
- g. The VFD shall have a specific “Pump cleaning” functionality, based on a series of rapid reverse and forward rotation of the impeller, to prevent pump and pipe clogging.
- The VFD shall have the cleaning cycle counter and user-programmable cleaning count time to give a warning and indicate the need for manual inspection.
  - The cleaning function shall consist of forced stopping, reverse and forward rotations to allow debris to be removed from the impeller.
  - There shall be a cleaning cycle status visible on the control panel screen when the cleaning function is active for monitoring the cleaning progress.
  - The VFD shall resume normal operation after the cleaning cycle is complete.
- h. The VFD shall have a programmable Sleep functionality for PID control in pumping systems to stop the pump during low demand.
- The VFD shall have a specific “Sleep Boost” functionality to minimize the amount of unnecessary pump starts and stops during periods of low demand. The sleep boost function is used to boost the pressure or water level up before the pump shuts down in order to extend the pumps sleeping time.
- i. The VFD shall support a torque boost function for applications where boosting of the torque is required for initial starting of the pump.

## B. PID control

- a. The VFD shall have a minimum of two independent process PID controllers as standard, allowing pressure or flow signals to be connected to the VFD, using the microprocessor in the VFD for the closed loop control.
    - The VFD shall have 250 mA of 24 VDC auxiliary power and be capable of loop powering a transmitter supplied by other suppliers.
    - The loop controller setpoint shall be adjustable from the VFDs control panel, analog inputs, or over the serial communications bus.
    - The VFD shall have a minimum of four constant setpoints available for each loop controller.
    - The setpoint shall be possible to be set and displayed in engineering units. Using only percentage as setting and display unit is not acceptable.
    - There shall be two parameter sets for the first PID loop controller. Switching between the sets shall be possible via digital inputs, timed function, and serial communications or from the control panel.
  - b. All setpoints, process variables, etc. shall be accessible from the serial communication bus.
  - c. The VFD shall have the ability to calculate air or water flow from pressure difference. There shall be the possibility to use a differential pressure transducer or two separate pressure transducers. The control panel shall be able to display the flow in engineering units.
  - d. PID controller shall be standard in the VFD, allowing an analog input signals to be connected to the VFD for the closed loop control. The VFD shall have 250 mA of 24 VDC power to power an external transmitter supplied by others. The loop controller set-point shall be adjustable from the VFD control panel, analog inputs, or over field bus. The set-point shall be set and displayed in engineering units.
- C. Function block programming
- a. The VFD shall provide a PLC-like programming capability as standard.
  - b. It shall be possible to use different kinds of arithmetic, logical, selection, comparison and operation function blocks to monitor and control the VFD, functions, inputs, outputs and variables.
  - c. There shall be a possibility to run different kinds of function block programs in different states and to set the criteria, when to change the state.
- D. Timed functions
- a. A real-time clock and calendar shall be available as standard for giving true time and date information to fault event history. The real-time clock shall have a minimum of 10 years power-off back-up without optional components. Back-up battery shall be replaceable without opening the VFD enclosure
  - b. A real-time clock shall be possible to use with timed functions, which shall allow controlling the VFD and its functions based on: time of the day, day of the week, seasons of the year, holiday periods and holiday dates and special working periods and working days
  - c. Timed functions shall be possible to use for: starting and stopping the VFD, for selecting the speed reference, for selecting the PID loop controller's set-point, for controlling the relay outputs, for selection the control location, for giving the run permissive or interlock signal to the VFD, etc.
  - d. There shall be the ability to temporarily override the time controlled start and start the and/or its functions regardless of: the time of the day, day of the week, season of the year, holiday, or workday.
- E. Fault Logger: A fault logger shall accommodate seven diagnostic values together with a date and time stamp.

- F. Built in Energy Calculators: There shall be built-in counters for calculating energy savings achieved with the VFD.
  - a. Used and saved energy
  - b. CO2 reduction
  - c. Saved money
  - d. Programmable kW rate
- G. Pre-Set Speeds: There shall be a minimum of seven programmable pre-set speeds or frequencies.
- H. Operating Values: All applicable operating values shall be capable of being displayed in engineering (user) units. A minimum of three operating values from the list below shall be capable of being displayed at all times. Engineering units shall be freely configurable for the user to display.
  - a. Output frequency
  - b. Motor speed (RPM, %, or engineering units)
  - c. Motor current
  - d. Calculated motor torque
  - e. Calculated motor power (kW)
  - f. DC bus voltage
  - g. Output voltage
  - h. Energy Consumption
- I. Underload and overload curves shall be user-definable.
- J. Independently adjustable acceleration and deceleration ramps with 1 to 1800 seconds adjustable time ramps. There shall be a possibility to use start delay before acceleration to ensure that all start conditions have been fulfilled.
- K. Changed parameters list shall be available in order to assist commissioning and troubleshooting.
- L. The VFD shall include pass code protection against unauthorized parameter changes. The pass code and the protection level shall possible to be defined by the user.
- M. The VFD shall have ability to use any internal parameter value as input for any other parameter
- N. The VFD shall have the capability to fault or to show warning when triggered from external sources.

#### EA13.2.5 Protections

- A. The following protection functions shall be available:
  - a. Dry pump Protection: (Prevent the pump from running dry. Protects the pumps bearings and shaft seal from damage when there is no water in the pump)
  - b. Overvoltage and under-voltage controller
  - c. Ground Fault (Earth-leakage) supervision
  - d. Motor short-circuit protection
  - e. Output and input switch supervision
  - f. Overcurrent protection
  - g. Phase-loss detection (both motor & line)
  - h. Underload and overload supervision
  - i. Freely configurable supervisions for any parameter or signal to trigger an action.
  - j. Communication loss functionality to ensure uninterrupted operation.
  - The VFD shall have the capability to change the control location from PLC to another external location identified by user, e.g. VFDs embedded PID/loop controller and change back when communication is recovered.
- B. The VFD shall have pump protection functions for flow and pressure to avoid damages of the pump and for leakage detection.

- a. Inlet protection for avoid dry run, cavitation and blocked pipe.
- b. Outlet protection for avoid high pressure and leakages.
- c. Stall protection for avoid running locked pump.

#### EA13.2.6 User Interfaces

##### A. Detachable control panel

- a. The control panel shall be detachable in all types of VFD protection classes and/or enclosures, without tools to allow easy commissioning and programming of multiple VFDs.
- b. The control panel shall include a backlit LCD.
- c. The control panel shall have a real-time clock with battery backup for adding time stamps to events, as well as for use with timer functions.
- d. The control panel shall provide a clear, interactive, context sensitive menu based user interface to make it easy to adjust the settings of the VFD.
- e. The display shall be in complete words, in a language selectable by the user, for programming and fault diagnostics (alphanumeric fault codes are not acceptable).
- f. The control panel shall provide interactive assistants (wizards) to help to commission and use the VFD.
- g. A dedicated "Help" button shall be available on the control panel. The Help button shall provide context sensitive assistance for programming and troubleshooting.
- h. The control panel shall provide an easy to use I/O menu, where the user can see the status and function of all the analog and digital inputs and outputs.
- i. The control panel shall have a menu, which contains diagnostic data about the VFD operation. The data shall include data about active faults, warnings and events. In addition the data shall contain a summary of VFD active control sources.
- j. There shall be an editable home-view in the control panel to allow different customer specific configurations.
  - A minimum of three operating values shall be capable of being displayed at all times.
    - All applicable operating values shall be capable of being displayed in engineering (user) units.
    - Engineering units shall be freely configurable for the user to display.
1. The control panel shall include Hand-Off-Auto selections and manual speed control.
  - The VFD shall incorporate "bump-less transfer" of speed reference when switching between "Auto" and "Hand" modes.
  - It shall be possible to disable the Hand and Off buttons of the control panel.
  - As a safety feature, the control panel's Hand and Off buttons shall have clear symbols to allow non-English speaking people to understand the meaning of the buttons. English text only is not acceptable in the Hand and Off button marking.
- k. There shall be a possibility to reset the VFD from the control panel.
- l. The VFD shall have the capability to change the output phase rotation sequence by use of a parameter. This parameter must be independent from, and not affecting, any speed reference or direction input to the VFD.
- m. The VFD shall have the capability to run the motor in either direction, forward or reverse. Additionally, the VFD shall allow for forcing the direction in a given direction, regardless of the speed reference or direction input to the VFD.
- n. A listing of changed parameters shall be readily available in order to assist with commissioning and troubleshooting.

- o. The VFD shall have flexible selections within a parameter. Not only shall the parameter have a list for easy selection, when applicable, but also the ability to choose any other signal/parameter that may not be within the list.
- p. The VFD shall include pass code protection against unauthorized parameter changes. The pass code and the protection level shall possible to be defined by the user.
- q. The control panel shall contain at least one back-up of the VFD settings. Back-up information shall be possible to be saved on the control panel both manually and automatically.
- r. The control panel shall have the capability to copy VFD settings from one VFD to another VFD, regardless of the VFD power, voltage or enclosure rating.
- s. The control panel shall have an editable "Contact info" that shows up in case of a fault.
- t. The user shall be able to take a screen capture snapshot of the display with the control panel and be able to download the screen capture for user's computer for further purposes.
- u. The user shall be able to connect a PC tool with a standard USB cable to the control panel in order to set up and control the VFD. It shall be possible to connect the USB cable without using any tools.
- v. The VFD shall provide a possibility for wireless communication to allow working outside the arc flash boundary area and/or when there is no easy or safe access to the VFD. Wi-Fi connection is not acceptable because of its cyber security limitations.
  - For safety reasons, the VFD supplied with wireless communications shall have a local control panel with control buttons regardless of the wireless connection possibility.

**B. Serial communications**

- a. The VFD shall have an EIA-485 (RS-485) port for serial communications as standard.
- b. The VFD shall be equipped with built-in fieldbus communication of type Modbus RTU
- c. There shall be following optional protocols available as plug-in and inbuilt options:
  - EtherNet/IP, Modbus/TCP, CANopen, DeviceNet, PROFIBUS-DP, PROFINET.
  - Protocols that have a governing authority shall be certified. Use of non-certified protocols is not allowed.
  - The use of third party gateways or multiplexers is not acceptable and all communication modules shall fit inside the enclosure of the VFD.

Serial communication capabilities shall include, but not be limited to: run-stop control, speed set adjustment, proportional/integral/derivative (PID) control adjustments, loop controllers' set-point adjustment, current limit, acceleration/deceleration time adjustments and lock and unlock the control panel.

### **EA13.3 Execution**

#### **EA13.3.1 Documentation**

- A. Documents to be delivered with the VFD:
  - a. Multi-lingual quick installation and start up guide.
  - b. Mounting template in case of wall mountable VFD.
  - c. Hardware and firmware manuals on request, describing step-by-step how to install, start-up, trouble-shoot and maintain the VFD.
- B. Documents to be delivered per request
  - a. Dimensional drawings (dwg and pdf formats).
  - b. Dimensional drawings 3D (stp format).

- c. Customer connections and power wiring diagrams (dwg and pdf formats).
- d. Cooling air requirement (xls and pdf formats).
- e. Manufacturer's statement on output currents available continuously in different ambient temperatures up to 40 °C. Type of product needed at 50 °C continuous (24/7/365) operation must be clearly listed.
- f. Environmental information / Recycling instructions of the VFD.
- g. Semi F47 statement.
- h. Harmonics statement EN61800-3-12.
- i. Routine test reports.

C. ePlan macros shall be available for all the wall mountable frames and modules.

#### EA13.3.2 INSTALLATION

- A. Installation shall be the responsibility of the installation contractor. The contractor shall install the VFD in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.
- B. Power wiring shall be completed by the electrical contractor, adhering to local electrical codes, wiring requirements based on the VFD input current. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.

#### EA13.3.3 START-UP

- A. A factory-authorized service technician shall perform start-up on each VFD.

#### EA13.3.4 PRODUCT SUPPORT

- A. The VFD manufacturer shall have an international sales, service, training and support network. These services shall be available in the local language.
  - a. The VFD manufacturer shall supply 24/7/365 technical phone support at no additional expense.
  - b. Training shall include installation, programming and operation of the VFD, and serial communication. Factory authorized start up and owner training to be provided locally upon request.
- B. The VFD manufacturer shall be capable to offer spare parts support the product.
- C. The VFD manufacturer shall have an analysis laboratory to evaluate the failure of any component within the VFD.

#### EA13.3.5 WARRANTY (Selection required)

- A. The VFD shall be covered with a worldwide warranty of a minimum of 36 months from the date of delivery.
- B. An optional extension of warranty of up to 60 months shall be available.

### EA14 **MV SWITCHGEAR**

#### EA14.1 **Quality Assurance**

##### EA14.1.1 Codes and Standards

The MV switchgear supplied shall comply fully with the applicable SANS specifications as set out in the table below and all equipment shall bear the mark of approval of the South African Bureau of Standards. The latest issue of the SANS/IEC/ NRS codes will be applicable:

<b>Standards List</b>	
<b>Number</b>	<b>Description</b>
SANS 62271-1	High-Voltage switchgear and controlgear, Part 1: Common specifications
SANS 60044	Current transformers and Voltage transformers
SANS 1091	National colour standards
NRS 003 / SANS 1885	AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 36 kV
NRS 012	Cable terminations and live conductors within air insulated enclosures (insulation co-ordination) for rated a.c. voltages of 7,2 kV and up to and including 36 kV
SANS 1019	Standard voltages, currents and insulation levels for electricity supply
SANS 1574	Electric cables - Flexible cords and flexible cables
SANS 60044-1	Instrument transformers - Part 1: Current transformers
SANS 60044-2	Instrument transformers - Part 2: Inductive voltage transformers
SANS 60265-1	High Voltage Switches-Part 1, High voltage switches for rated voltage above 1 kV and less than 52 kV
SANS 62271-100	High-voltage switchgear and controlgear, Part 100: Alternating-current circuitbreakers
SANS 62271-200	High-voltage switchgear and controlgear, Part 200: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV
SANS/IEC 62271-102	High-voltage switchgear and controlgear, Part 102: Alternating current disconnectors and earthing switches
NRS 012/SANS 876	Cable terminations and live conductors within air-filled enclosures (insulation co-ordination) for rated A.C voltages from 7,2 kV up to and including 36 kV
NRS 053/ SANS 1332	Accessories for Medium-Voltage Power Cables (3,8/6,6 kV to 19/33 kV)
SANS 97	Electric Cables: Impregnated paper insulated metal sheathed cables for rated voltages from 3,3/3,3 kV up to 19/33 kV
SANS 1339	Electric cables - Cross-linked polyethylene (XLPE) - insulated cables for voltages from 3,8/6,6 kV to 19/33 kV
SANS 10198	The selection, handling and installation of rating not exceeding 33 kV - Part 10: Jointing and termination of paper insulated cables
SANS 10142-1	The wiring of premises Part 1: Low voltage installations
SANS 10142-2	Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 MVA installed capacity
IEC 60255	Measuring relays and protection equipment

#### EA14.1.2 Manufacturers

Compliance with the applicable specifications is required, products of the following manufacturers will be acceptable:



- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

#### EA14.1.3 Installers

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

### EA14.2 Medium Voltage Switchgear – Requirements

#### EA14.2.1 System and Operating/ Environmental Conditions

The relevant items detailed in Technical Schedule EB3 are for use in indoor enclosures which form part of eThekweni Water and Sanitation medium voltage (11 kV) system and shall be designed to operate satisfactorily when subjected to the following operating conditions:

Description	Detail
Climate	humid and sub-tropical
Altitude	from sea-level to 1 000 m
Ambient temperature	from 0°C to 50°C
Maximum relative humidity	99 %
Highest system phase-to-phase voltage	12 kV
System frequency	50 Hz
System neutral earthing	solidly
Rated normal current	630 A
Fault level	25 kA
Service configuration of switchboard	In-line extendable to form a continuous bank

#### EA14.2.2 General Description

The circuit breaker panels required shall be of the universal type wired for overcurrent/earth fault, sensitive earth fault and single mode cable differential protection and the panels shall be suitably blanked to accommodate the following relay options:

- **Incoming circuit breaker – with protection (PX class) current transformer wired for cable differential protection, overcurrent, earth fault protection, sensitive earth fault protection, auto-reclosing functionality and internal arc detection protection.**
- Distributor circuit breaker – with protection (PX class) current transformer wired for cable differential protection, overcurrent, earth fault protection, sensitive earth fault protection, auto-reclosing functionality and internal arc detection protection.
- Distribution circuit breaker – with voltage transformer and protection class (5P20) current transformers, measuring class (0,2) current transformers wired for overcurrent, earth fault protection, sensitive earth fault protection, auto-reclosing functionality and internal arc detection protection.

The communication and SCADA requirements will enable remote monitoring of the switchgear.

Note: When the switchgear is locked-out, the electrical operation shall be inoperative.

#### EA14.2.3 Design and Construction

##### A. General

- The metal enclosed switchgear shall comply with NRS 003/SANS 1885 and SANS 62271-200.
- Circuit-breakers shall be designed in accordance with SANS 62271-100.
- The circuit-breaker shall be of the fixed type and comply with the requirements of clause 4.3.3 of SANS 1885/NRS 003.
- The circuit-breaker shall be fixed and compact, maximum dimensions of which is specified in Technical Schedule EB3.
- The circuit breaker shall have definite mechanical indication, clearly visible from the front of the panel, to show the following:
  - Circuit-breaker open and closed indications, which shall be visible with the circuit-breaker in any position, where applicable;
  - Stored energy device charged or discharged; and
  - Earth-position indication.
- The primary insulation (where arc interruption occurs) of circuit-breakers shall be of the vacuum type. All secondary insulation shall be either controlled air, SF6, screened solid or a combination.
- The circuit-breaker operating mechanism shall be an integral part of the circuit-breaker unit.
- The mechanism for closing the circuit breaker shall be initiated electrically and the opening shall be both electrically and mechanically. These devices shall be suitable for operation at any voltage between 70 % and 110 % dc, as measured at the terminals of the device. The circuit breaker shall close when an electrical pulse of 100 ms is applied to the closing coil.
- In the case of a spring-charged closing mechanism with a coil-operated release, the total coil power shall not exceed 1,5 kW per circuit breaker.
- Adequately rated "a" and "b" control contacts shall be provided on each breaker.
- The electrical tripping circuit of the circuit-breaker shall be isolated when the circuit-breaker is in the earthing position.
- A mechanical trip facility shall be provided with a locking off facility. The locking off facility shall be manufactured from mechanically robust material due to the use of locks and callipers. The trip button as well as the orifice for any operating handle shall be able to be locked off.
- Provision shall be made for electrically opening and closing of the circuit breaker via a remote pendant switch which is at least 3 m in length.

##### B. Earthing Switches

- Each panel excluding the bus-section panel shall have circuit side (power cable) earthing facilities that are rated for fault-making and is tested in accordance with SANS IEC 62271-102.
- Circuit-side earthing shall be of an integral earthing type either to the circuit breaker or the panel.
- All earthing switches and earthing devices shall be fully rated for the specified short time withstand of the panel.

- The frame of each earth switching device shall have a reliable earthing terminal that has a clamping bolt for connection to an earth conductor rated for the specified fault conditions. The diameter of the clamping bolt shall be at least M12.
- Each switchgear panel shall include a copper earthing bar at least 25 mm wide with a cross-sectional area of at least 125 mm<sup>2</sup>, to facilitate earthing of cable sheaths and armour. The earth bar shall be suitable for interconnection to the adjacent switchgear panels. The current density in the earthing conductor shall be 200 A/mm<sup>2</sup> minimum. If the earthbar is exposed to the atmosphere it shall be tinned.
- All exposed earth busbars shall be manufactured of aluminium alloy. Test for short time current need not be done, however, this shall be proven by calculation.

#### C. Cable Test Facility Requirements

- Integral cable test facilities shall be accessible from the front of the circuit breaker panel and independent of the cable termination enclosure. Note: Separate cable test facilities that are independent of the cable termination enclosure eliminates the need to access and interfere with the cable terminations for cable testing. If separate cable test facilities are not provided, access to the cable termination enclosure is required to test the cable and this may compromise the internal arc classification of the switchgear if the other functions are live. Replacement of separable connectors or their associated test points and caps after testing will require cleaning and re-lubrication.
- Where separate cable test facilities that are independent of the cable termination enclosures are provided, it shall be possible to connect cable test equipment (e.g. pressure testing or fault locating equipment) to the cable through the cable test facility without compromising the IAC of the circuit breaker panel.
- The type of cable test facility offered shall be stated in Technical Schedule EB3. Details of the design shall be provided with the bid documentation.
- Each cable test facility shall be interlocked with its associated earth switch to ensure that the test terminals of the cable test facility are not accessible when the cable is energized. Access to the test terminals of the cable test facility shall only be possible when the associated earth switch is in the EARTH position.
- Where removable short-circuiting connections are provided for cable earthing (e.g. a removable star point connection), the re-instatement of these connections following cable testing shall not require the use of tools and/or the application of specific torque settings. This implies that no bolted connections are accepted. It shall not be possible to close the cable test facility if the short-circuit connections have not been re-instated. It shall not be possible to physically remove the short-circuiting connections from the switchgear. Note: Consideration should be given to measures intended to prevent theft of the short-circuiting connections.
- Where test probes are required in order to carry out cable testing, a complete set of three test probes shall be supplied with each circuit breaker panel and securely mounted at a readily accessible location on the inside of the access cover.

#### D. Enclosure

- Enclosures shall be metallic and have a degree of protection of IP3X according to Table 7 of SANS 62271-1
- Covers or doors that give access to tool-based accessible power compartments shall comply with clause 5.102.2(a) of SANS 62271-200.
- Covers or doors that give access to interlocked accessible power compartments shall comply with clause 5.102.2(b) of SANS 62271-200.
- Inspection windows shall comply with clause 5.102.4 of SANS 62271-200.

- Service continuity of the switchgear shall be category LSC-2A.
- The switchgear shall have a partitioning class that shall be PM as specified in clause 3.109.1 of SANS 62271-200.
- The door for the LV compartment shall have a three point locking mechanism.

E. Internal Arc Classification

The switchgear shall be tested according to SANS 62271-200, with the following additional requirements:

- All power compartments shall be tested i.e. "busbar compartment, circuit breaker compartment, cable compartment and current transformer compartment".
- All panels shall be tested with the correct size current transformers.
- Where power cables impede the venting of the compartment, they shall be installed for testing purposes.
- Test shall be carried out according to "Type A" i.e. "Metal-enclosed switchgear and controlgear with accessibility restricted to authorised personnel only".
- The testing conditions shall be represented as close as possible to those of normal service. They shall be represented by a floor, the ceiling above the top of the power compartments, lateral and rear walls. The clearance of the room simulation shall be in accordance with clause AA.3 (a) of SANS 62271-200. The arrangements of the cotton indicators shall be in accordance with clause AA.2 of SANS 62271-200.
- Test voltage, current and duration for 11 kV panels shall be 12 kV/25 kA for 1 second.
- The internal arc classification shall be IAC AFLR.

Note: All switchgear panels shall be fitted with an internal power arc detection and clearance protection system.

F. Cable compartment, Terminations and Competency Requirements

a. Cable Compartment

- Cable compartments shall be suitable for the termination of cables in air and shall comply with the requirements of NRS 012.
- The cable trench below the cable termination compartment is fitted with chequer plates. The method of supporting the cable shall not interfere with the removal of these chequer plates. Furthermore, it sometimes collects free water, therefore the cable box design shall cater for condensation.
- Bushings shall be screened Type C dimensions in accordance with EN 50181.

b. Cable Terminations

- The phase sequence on all cable terminations shall be identical on all panels in the switchboard.
- The successful Tenderer shall be responsible for the supply and installation of the cable terminations and connectors.
- Requirements of Screened Separable Connectors (SSCs)
  - SSCs shall be supplied as a complete indoor termination kits in accordance with clause 4.1.4 of NRS 053/SANS 1332 and as specified in this technical specification.
  - SSCs shall be of the dead-break, bolted contact type and shall be suitable for connecting to an outside cone plug-in type bushing with interface type 'C' having an M16x2 thread.

- The SSCs shall be able to accommodate 35mm<sup>2</sup>, 50mm<sup>2</sup>, 70 mm<sup>2</sup>, 95 mm<sup>2</sup>, 150 mm<sup>2</sup>, 240 mm<sup>2</sup> and 300 mm<sup>2</sup> (3 cores cable sizes and types).
- Each SSC shall be supplied with a stainless-steel fixing stem and all associated components (e.g. end plug, test point cap).
- SSCs shall be supplied in sets of three in a complete termination kit, i.e. allowing for the termination of one three-core cable.
- SSCs shall be supplied with lugs suitable for the standard ranges specified in this specification.
- Where SSCs are provided with an external length of insulated conductor that is required for the earthing of the SSC housing, the conductor shall be:
  - An insulated copper conductor of nominal cross-sectional area of at least 4 mm<sup>2</sup>,
  - Of length 700 mm, and
  - Terminated at the non-SSC end with a lug having an M12 fixing hole.
- Earth Components of Cable Termination Kit
  - The main earth conductor of the termination kit shall be a 70 mm<sup>2</sup> tinned copper braid.
  - The main earth conductor shall be 700 mm in length.
  - The main earth conductor shall be terminated with a tinned copper lug that has a M12 fixing hole.
  - The earth fault current rating of the main earth conductor is limited to 10 kA for 1 second.
  - The main earth conductor shall be water blocked to prevent ingress of moisture into the cable termination. The positioning of waterproofing shall be clearly indicated in the installation instructions.
  - The main earth conductor of the cable termination kit shall be connected to the steel wire armour of the cable either with constant forces springs, fixed over layers of tinned copper mesh.
  - A 16 mm<sup>2</sup> earth braid together with a constant force spring shall be used to earth each copper tape screen of each core of the cable to the steel wire armour of the cable.
  - The constant force spring shall have a minimum width of 20 mm and shall be suitable for the relevant cable dimensions.
  - Filler tape shall be used and suitably positioned to smoothen sharp edges around installed constant force springs. This filler tape shall also serve to restrain the springs.
  - Constant force springs that form part of the main earth connection shall not be used to secure any ferrous metal enclosures used for mechanical protection of the cable termination.
  - The constant force springs shall be suitable for the relevant cable dimensions.
- Requirements for Mechanical Torque Shear Connectors
  - Range taking mechanical torque shear lugs shall comply with dimensional requirements of Table 1 of Figure 1 of NRS 075 for the range 35 mm<sup>2</sup> to 300 mm<sup>2</sup> size conductors.
  - The mechanical torque shear connector shall be capable of connecting to the following combinations of conductors:
    - Both aluminium and copper;
    - Both round and sector shape; and
    - Both compacted and uncompacted.
  - The mechanical torque shear connectors shall be “Class A” as per SANS IEC 61238-1 and NRS 075.
  - The mechanical torque shear connector shall be capable of withstanding, without deterioration, the normal operating currents and short-circuit currents to which the electrical system may be subjected to.
  - Mechanical torque shear connectors shall be designed to connect both copper and aluminum conductors together without galvanic reaction.

- Mechanical torque shear connectors shall be free of surface and internal defects such as burrs, cracks, rolled seams, blisters, twists, press and chatter marks.
- Mechanical torque shear connectors shall be of a one-piece construction i.e. two dissimilar materials shall not be used in the construction of the connector barrel.
- The bore of the barrel of connectors shall be chamfered to facilitate easy conductor entry.
- The inside of the connectors shall be ridged (grooved) and the contact area greased with an anti-oxide paste (Mo-based) for corrosion protection. The bolts shall be greased with anti-friction grease.
- The mechanical torque shear connector shall be fitted with centered inserts to be used for centering conductors of smaller cross-sectional area.
- Center rings shall be colour coded indicating the different conductor sizes and/or the conductor size shall be marked indelibly on the inserts.
- The mechanical torque shear connector shall be rated on the current carrying capacity of the largest conductor of the range.
- Test Requirements
  - Complete termination kit for impregnated paper insulated cables shall meet test requirements of NRS 053/ SANS 1332 for specified rated voltage of the cable.
  - Complete termination kit for cross linked polyethylene insulated cables shall meet test requirements of NRS 053/SANS 1332 for specified rated voltage of the cable.
  - The acceptance of alternative test reports shall meet requirement of NRS 053/SANS 1332.
- Test Reports and Certification
  - Test Reports shall meet requirement of NRS 053/SANS 1332.
  - A complete Test Report certifying that the kit offered meets requirement of NRS 053/SANS 1332 shall be included in the bid.
- Testing after Installation

The successful Tenderer shall ensure that after the installation of the cable termination onto the switchgear, the power cables shall be tested at a value specified for cables complying with SANS 10198-13 for XLPE cables and SANS 97 for PILC cables, for the same system voltage as the switchgear. The test results shall be submitted to Engineering Support: MV/LV Operations.

G. Competency Requirements

Competency of staff undertaking installation of the cable terminations and connectors

- a. The name/s of the Electrical Artisans shall be listed in the submission.
- b. The Successful Tenderer shall ensure that prior to orders commencing, the Electrical Artisans listed in the submission are sent to eThekwini Electricity Training Centre to be deemed a Competent Person on the following:
  - eThekwini Electricity's Codes of Practice;
  - eThekwini Electricity's Safety Rules;
  - eThekwini Electricity's Underground Mains; and
  - eThekwini Electricity's Substations.

**The cost of this training shall be borne by the Successful Tenderer.**

- c. The Head: eThekwini Water and Sanitation , his/her representative will have the right at any time to summon the Successful Tenderer to the site of works to attend to defects or breakdowns on work undertaken by him/her, and failure of the Successful Tenderer to respond promptly to such calls will be regarded as a breach of the contract. The Successful Tenderer shall provide the Head: eThekwini Water and Sanitation with a list of the names, addresses and telephone numbers of his (the Successful Tenderers) employees who are available to be summoned for this purpose, and such list shall be kept up to-date.

The Successful Tenderer agrees that, in and about the execution of the contract, he will not contract any other than regular and duly qualified and competent persons to do such work as is

usually done by skilled workmen in contracts of this nature. No work shall be done unless carried out under the direct and personal supervision of the Competent Person referred to above. Any contractor of the Successful Tenderer who is not deemed a Competent Person, or who shall act in an improper manner, shall be removed by the Successful Tenderer on the order of the Head: Electricity and such person shall not again be employed for the purpose of this contract without permission from the Head: eThekweni Water and Sanitation or his representative.

H. Busbars

All busbar systems shall be solid shielded screened isolated. All busbars shall be rated to carry 630 A. The bus-section shall also have a rating of 630 A. End panels of the switchgear shall allow for future extensions.

I. Current transformers

- Current transformers shall comply with the requirements of SANS 60044-1. Only ring type CT's will be considered for evaluation. The CTs shall be housed either within a separate power compartment or around the cable bushings. CTs shall not be housed around the power cables.
- The class and ratio of all current transformers are specified in Annexure B
- The number of current transformers shall conform with the requirements listed in Annexure B
- The limits of temperature rise of the windings of the current transformers at the full load continuous primary current rating of the switchgear panel shall comply with SANS 60044-1.
- All current transformers shall be naturally air cooled. Their secondary terminal connections shall be safely and readily accessible with the circuit isolated. The current transformers in the switchgear panel shall be readily accessible with only the circuit-side isolated for removal/replacement without extensive dismantling of primary circuits.
- All the current transformers shall have a short-time current rating of not less than the short-time current rating of the associated switchgear panel.
- Current transformers specified for overcurrent and earth fault protection may also be used for indicating instruments provided that the current transformers are suitably rated and accuracies can be maintained within the specified limits. If these CTs are to be used then the instrument shall be fitted with saturation CTs.
- Each current transformer shall be fitted with rating plates.
- Approved means should be incorporated to allow primary injection testing to be carried out after the panel is in service.
- All terminals of the current transformers shall be terminated individually into shorting blocks in the relay compartment to facilitate changing of the star point and ratio.
- Metering class current transformers shall only be fitted for metering incomers.
- All incoming circuit breaker panels shall be wired with 500/1 current transformers.
- All distribution circuit breaker panels shall be wired with 500/1 current transformers.
- All incoming circuit breaker panels that require an extended cable box for the termination of two cables shall be wired with 1000/1 current transformer.

J. Voltage transformers

- Voltage transformers shall be fitted and this shall be specified at the time of order.
  - Voltage transformers shall comply with the requirements of SANS 60044-2 and should be of the encapsulated type that is totally encapsulated in epoxy resins or other suitable material.
  - Fixed or withdrawable type voltage transformers shall be fitted in a metal screen, which shall be earthed.
  - Voltage transformers shall be so arranged that they can be isolated and removed when the associated circuit is dead.
  - The voltage transformer primary bushings shall be connected to the circuit-side.
  - The voltage transformer unit shall be complete with low voltage fuses.
  - Lockable metal shutters for withdrawable voltage transformers shall be provided to cover the fixed isolating contacts automatically when the voltage transformer is withdrawn/removed. Padlocking facilities shall be provided for locking these shutters in the closed position and for locking the voltage transformer in the isolate/removed position.

- Voltage transformers shall be utilized as a back up to trickle charge the battery charger unit installed in each distributor substation. The primary supply to the battery charger unit will be via a dedicated AC plug outlet. In the event that the dedicated AC plug outlet fails to supply AC, an auxiliary mechanical relay shall then operate causing this voltage transformer to drive the battery charger circuit.

The VT shall be designed as follows:

- a. for connection to the busbar side;
- b. 11 kV to 110 VAC;
- c. VT factor: 1,9 for 8 hours;
- d. Minimum Burden: 2 500 VA

Note: The rating of the relay contacts shall be 10 A.

#### EA14.2.4 Instruments

All instruments shall be flush-mounted industrial type instruments that comply with the requirements of the relevant parts of IEC 60051.

- A combined ammeter/thermal maximum demand indicator shall be provided and shall be withdrawable and interchangeable. Automatic shorting of the CT terminals shall occur when the ammeter is withdrawn. The ammeter shall be provided with a scales of 0-500 A. The ammeter shall be suitably protected from damage as a result of the conduction of full rated fault current through the associated switchgear and shall therefore be fitted with saturation CT's. The ammeter shall be wired directly into the white phase CT secondary wiring and no selector switch must be provided.
- Note: Should an extended cable box option as detailed in 5.9.14 be ordered then the ammeter and respective scale shall be 0-1000 A.
- The required instruments ammeter, alarm cancellation switch, local/remote switch, CT test block, trip test jack plug and luminous indicator and protection relays shall be provided on the switchgear and shall be clearly visible and operable from a standing position in front of the relay compartment. With respect to bus-section relay compartment the required instruments is an alarm cancellation switch, local/remote switch, an open and close switch and open/close plug.

#### EA14.2.5 Protection Relays

##### A. General

All protection relays shall be a numerical type microprocessor and shall be IEC 61850 ed 2 compliant.

The Incoming or Distributor panel shall be fitted with one protection device only. This protection device shall be able to provide all functions as detailed in Section D.

All protection relays shall be of the flush mounting, withdrawable type and shall be contained in dust-proof cases (IP55 rating) with an interior finish of aluminium or other approved material. The relay shall provide a push button to RESET the indications in such a manner that does not require the removal of the dust proof case and does not compromise the IP rating.

The relays shall be withdrawable and interchangeable between respective panels (distributor or incomer) in such a manner that it does not require relay logic configuration and panel wiring changes.

The relay shall have a self-monitoring contact that would provide an alarm in the event of complete or partial relay failure.

The relay shall have a dedicated engineering access via a front Ethernet port.

All DC operating voltage range for all protection relays shall be in the range of minus 20 % to plus 20 % of the nominal battery voltage.

Numerical relays shall have a keypad and LCD type interface accessible from the front. This



shall provide a facility to amend settings manually from the keypad.

Relays shall have a minimum of 10 user programmable LEDs.

The relay LCD shall display text messages which shall default to the phase currents and voltages when the relay is in normal service. Relays shall be provided with a LCD mimic to indicate the status of the switchgear and measured values in the panel. In this case, the display shall default to the mimic.

Where tripping and closing contacts are required, these shall be adequately rated and monitored.

All alarms shall be published from the respective IEC 61850 logical nodes.

Temperature monitoring shall be made available on the inside of one of the panels closest to the SCADA gateway through the protection relay via the STMP logical node. This value shall be reported back to the Control Centre.

Test and maintenance mode shall be made available as defined in IEC61850-5.

Remote login functionality into all relays through a web browser shall be available to view and update configuration settings.

All relays to support the ability to view settings and real-time information via a web server hosted on the relay.

All relays to support the ability to automatically upload disturbance record files to a remote file server

The IEC 61850 configuration of the relay shall limit the use of GGIO. The relay shall support the Logical Nodes defined in IEC 61850-7-4 for the functions included in this tender.

B. Logic capabilities and engineering functions

The relays shall have an event configurable oscillographic recording capability for at least 6 events. The relay shall be programmable to select whether storage of recordings are non-overwriting or overwriting (i.e. first in, first out). Oscillographic recordings shall be available in "COMTRADE" format.

All control logic functionality should be implemented within the relay. Where auxiliary contact copying relays and/or timers are required in protection schemes, these shall be protection class and the use of these shall be to the approval of the Engineer.

The relay shall be capable of accepting the changing of individual protection settings while in service.

Engineering functions and programming of the relay shall be possible using a PC via a 100BaseT port on the Substation Ethernet Switch using software that shall operate on the latest version of Microsoft Windows.

C. Communication requirements of protection relays

All relay communication required for the implementation of the Substation Automation System shall comply with IEC61850. A Protocol Implementation Conformance Statement (PICS) and Model Implementation Conformance Statement (MICS) for each relay model shall be included in the bid submission.

Each of the relays shall have the following communication facilities for substation LAN communication:

- 100BaseT Ethernet port at the back of the relay, according to IEEE 802.3u. This port shall be used for IEC 61850 communication, protection engineering functions and configuration.

#### D. Protection Functions

A composite protection relay shall be supplied per panel with the following functionality:

- **Incomer:** Overcurrent, Earth Fault, Sensitive Earth Faults, Thermal Protection, Negative Sequence, Undervoltage, Overvoltage, CT Supervision, Internal Arc and Cable Differential capabilities in one unit.
- **Distributor:** Overcurrent, Earth Fault, Sensitive Earth Faults, Thermal Protection, Negative Sequence, Undervoltage, Overvoltage, Internal Arc, Autoreclosing and CT Supervision capabilities in one unit.

These functions shall be in accordance with the following detailed specifications:

##### a. Overcurrent

- The overcurrent elements of the relay shall be of the inverse definite minimum time lag type with:
  - Adjustable settings from 10 % to 200 % (in steps of 1 %) of the normal full load secondary current of 1 A.
  - The time multiplier settings adjustable between 0 and 1 (in steps of 0,01).
  - Highset element I>> with definite time.
- These elements of the relay shall provide selectable alternative time/current characteristics and instantaneous settings for definite time operation.

##### b. Earth fault

- The earth fault elements of the relay shall be of the inverse definite minimum time lag type with:
  - Adjustable settings from 5 % to 80 % (in steps of 1 %) of the normal full load secondary current of 1 A.
  - The time multiplier settings adjustable between 0 and 1 (in steps of 0,01).
  - Highset element Ie>> with definite time.
- The earth fault elements shall be in accordance with Clause 8.4.1.2.

##### c. Sensitive Earth Fault

- The sensitive earth fault element of the relay shall be of the definite time lag type with:
  - Adjustable settings from 0,5 % to 10 % (in steps of 0,5 %) and of the normal full load secondary current of 1 A with definite time delay with settings between 0 s and 10 s.
  - An operative/inoperative switch shall be provided and an intermittent alarm shall be sent when the SEF is inoperative. The intermittent alarm shall be achieved by means of an unequal repeating timer (on time selectable between 1 to 30 seconds and off time selectable between 1 to 30 minutes). This could be achieved internal to the relay. Local indication lamp shall also be provided when the SEF is made inoperative. The SEF operative/inoperative switch, lamp and intermittent alarm relay shall be fitted to all panels.

##### d. Thermal Protection

- The thermal element of the relay shall provide input for heating and cooling time constants settable in minutes in the range of 3-600 for heating and 1-30 for cooling.
- The elements shall also provide inputs for pick up and alarm current levels in 0,1% steps in the range of 0,05 – 160.

The Cable Differential, CT Supervision, Negative Sequence, Undervoltage and Overvoltage elements shall comply with IEC 60255.

##### a. Differential Protection

- The differential protection function shall utilise single mode fibre communication links/channels. Fibre links shall be taken to the rear of each switch panel then to the central Communication Panel. The use of external media converters shall not be accepted. The differential protection element shall allow for mismatched CT ratios with a minimum factor of 4.
- The fibre cable differential relays shall have communication channel monitoring.

b. Buszone arc protection

All power compartments shall be fitted with an arc detection device.

- Arc detection device

The arc detection device shall be able to detect all possible arcs of different magnitude and spectrums that may occur in any power compartment. The arc detection device shall be monitored by the protection relay.

- Operating Philosophy
  - The operation of the buszone arc detection scheme shall be a minimum of 2 trip criteria (2 out of 2) and shall be user configurable i.e. light and current, light only, current only, etc
  - The arc detection scheme shall provide 2 zones of protection separated by the bus section breaker. In the event of the trip criteria being met in any panel in any zone, the arc detection scheme shall isolate that zone by tripping all respective panels in that zone including the bus section. The arc detection scheme shall indicate which arc detection sensor on which panel initiated the bus zone operation.
  - In the event of the failure of an arc sensor in a panel, the arc detection scheme shall disable the buszone arc detection scheme for that respective panel only and shall indicate an alarm accordingly.
  - Breaker failure: A breaker fail element shall be provided such that the respective zone in the buszone arc protection scheme is initiated in the event of a breaker fail condition for any panel.

#### EA14.2.6 Auxiliary and Secondary Wiring

- The auxiliary and secondary wiring shall comply with the requirements for panel/cubicle cables in SANS 1574, IEC 6022-3, IEC 6022-4 or IEC 6022-5 and shall withstand an a.c voltage of 2 kV to earth for 1 minute.
- All auxiliary and secondary terminals of wire shall be marked with wire markings. The markings shall be permanent black characters on a glossy contrasting colour background (preferred yellow). Both ends of the wire shall be marked identically, and shall be consistent with associated drawings, circuit functions and designations and shall comply with Annex A of NRS 003/SANS1885.
- All dc circuits shall be protected by fuses (black body) in the positive lead and links (white body) shall be provided in the negative lead.
- Fuses and links shall be so positioned that they are readily accessible to a person standing on the floor in front of the switchgear. Exceptions are fuses and links mounted on the voltage transformer.
- Suitable termination for auxiliary wiring, such as pilot wire connections for cable differential protection, battery supplies, alarm circuits, etc., shall be provided at the rear of each panel.
- The minimum external creepage and clearance distances between adjacent terminals and between terminals and earth shall be in accordance with the requirements of SANS 152.
- An additional alarm circuit shall be entirely separate from all other circuits and an alarm cancellation switch shall be provided. The alarm cancellation switch shall be of the double throw type, so connected as to avoid the possibility of the alarm cancellation switch being inadvertently left off, after the circuit breaker has been re-closed. The alarm pair of wires shall be terminated at the back of each panel. Further all alarms from the protection relays shall be individually brought back to the communication panel.

#### EA14.2.7 Protection against Corrosion

- The painting process is considered to be of major importance in the highly corrosive climate of the eThekweni area.
- The manufacturer shall ensure that the coating system used on the switchgear will satisfy the tests stipulated Section EA14.2.8.
- The metal shall be treated by means of a zinc phosphate process and thereafter powder coated by means of an electrostatic process.

#### EA14.2.8 Tests

##### A. General

- It shall be the responsibility of the supplier to ensure that type tests are valid. eThekweni Electricity may require drawings from the supplier to take to a testing authority for validity.
- Should reasonable doubt exist as to the validity of test certificates submitted, for example by virtue of modifications made to the switchgear, eThekweni Electricity may direct that further tests be carried out at a recognized test facility in the presence of a representative of the purchaser, on a sample unit of the switchgear in question. The cost of these tests shall be for the expense of the supplier.
- If switchgear of South African manufacture or assembly to overseas design is offered, test certificates relating to the South African complete switchgear assembly shall be submitted, and shall be accompanied by a statement that the South African manufactured unit is identical (this shall be verified by an accredited test authority in accordance with ILAC, see note below) with the overseas product and the number of such units already produced and installed in South Africa shall be stated.
- Note: Identical in terms of all design parameters as developed and tested by the original manufacturer.

##### B. Type test

The supplier shall prove the ability of the switchgear to pass all the mandatory type tests as stated in clause 6.1 a) to g), j), k), n) and o) and if applicable clauses h) and l) of SANS 62271-200. The supplier shall also provide a humidity test report.

##### C. Routine tests

The routine test shall be made on each transport unit at the manufacturer's works to ensure that the switchgear is in accordance with the equipment on which the type test has been carried out. All the routine tests shall be in accordance with clause 7.0 of SANS 62271-200.

##### D. Tests after erection on site

- All switchgear, once installed on site, will be subjected by the purchaser to 80 % power frequency voltage test in accordance with clause 7.105 of SANS 62271-200.
- All mechanical and electrical functional tests shall be done in accordance with Clause 20.2 Pre Commissioning Check Sheet of this technical specification.
- Resistance test on all primary connections at not less than 100 A and up to the rated current of the circuit.
- Primary injection tests with standard settings.
- Secondary injection tests with standard settings. The results shall be generated via the test set electronically. Example: omnicon or equivalent test set.

##### E. Tests on painted surfaces

Protection of coatings against corrosion shall be assessed using test samples of the same materials used in the construction of the switchgear and subjected to the same painting procedures as the switchgear. The following tests shall be performed:

- Adhesion test in accordance with SANS 2409: the cross-cutting coefficient shall be not less than 8.
- Exposure to salt fog for 168 h in accordance with latest version of SANS 9227: the coated surface shall show no visible defects and the underlying metal shall be free from corrosion and scale, and

- Scratch resistance test in accordance with SANS 279: when a mass-load of 1 kg is applied to the test needle, the scratch produced shall not have penetrated to the underlying metal. The scratch shall have no jagged edges.

#### EA14.2.9 Marking/Labelling

##### A. Main circuit designation labels

Main circuit designation labels shall be blank sandwich-board or equivalent (white-black-white) that can be removed easily for engraving. These shall be located on the front and back of each switchgear panel and shall be at least 150 mm wide and 35 mm high.

##### B. Rating plates

- All rating plates shall comply with the relevant requirements of clause 5.10 of SANS 62271-200 and shall be of intrinsically corrosion-resistant metal with the following details clearly, legibly and indelibly marked thereon:
  - a. the manufacturer's name;
  - b. the manufacturer's type number;
  - c. the manufacturer's serial number;
  - d. the year of manufacture;
  - e. the rated values;
  - f. the short-time withstand current; and
  - g. arc classification.
- Circuit-breaker rating plates shall comply with the requirements of SANS 62271-100, and shall include the actual ratings to which the circuit-breaker has been type tested. These shall be fixed in a position that is visible when the circuit-breaker is in the service position.
- Current transformer rating plates shall comply with the requirements of SANS IEC 60044, and shall be duplicated, one fixed to the current transformer, the other fixed in a conspicuous position on the corresponding circuit breaker panel, such that it can be read when the switchgear panel is in service.
- A main switchboard label shall be supplied with every switchboard. The label shall be mounted centre top of the switchboard. The font size shall be 30 mm in height. The material shall be corrosion resistant metal.

##### C. Function labels

- All relays shall be appropriately identified to indicate their function.
- All relays, instruments, fuses, control switches, luminous indicator, test blocks and links, the functions of which are not identified by signs or pictograms, shall be clearly labelled in text with black letters of minimum height 5 mm on a white background, to indicate their functions. All labels shall be securely attached.
- Fuse labels shall include the fuse rating.
- Where necessary, labels shall be repeated inside the switchgear.
- Terminal blocks or rail-mounted terminals shall be labelled to identify them when more than one block is used.
- Removable doors and panels shall be labelled to facilitate replacement in the correct position.
- Main circuit labels shall be either on a fixed portion of the panel or on a bracket. They shall not be fixed to removable doors.
- ON, OFF and EARTH position labels shall comply with clause 5.12 of SANS 62271-1.

##### D. Wiring labelling standard for SCADA Gateway

The following labeling standard shall be used:

##### Tele-Control Labeling

W	—	Control
X	—	Status Digital IP
XC	—	Current Analog
XE	—	Voltage Analog

Other Field Wiring

J12	–	DC unfused
A	–	Main protection Differential
B	–	Bus Zone
C	–	Backup Protection
T	–	Pilots
K	–	Fused DC
D	–	Metering
E	–	VTs
AL	–	Alarms (General)

E. Communication Network Labels

- All hardware components of the system shall be clearly labelled to indicate its purpose and designation. The switch shall be labelled with the IP address.
- All cables shall be labelled according to the specification by the eThekwini Electricity Communication Networks Branch.

EA14.2.10 Spares

Spares will not be ordered unless suppliers indicate up front that a particular spare is absolutely necessary to avoid long delays should a component fail. A list of critical spares shall be supplied.

EA14.2.11 General

- Switch panels may be rejected if not delivered complete, with all relays, instruments, rating plates and eThekwini Water and Sanitation number plates.
- Metering current transformers and voltage transformers shall be sent to eThekwini Electricity, Test Section, Control Centre, 1 Jelf Taylor Crescent Durban, 4001, for testing. The removal and subsequent installation of these instrument transformers in the panels shall be carried out by the successful Tenderer.

EA14.2.12 Supply, Delivery Assembly and CommissioningA. Ordering information

The order shall be placed in the following manner:

- Each order shall be placed for a set of breakers to form a switchboard.
- An MV schematic with all relevant information will be supplied with each order, which shall also detail the protection requirements.
- The address (any area within eThekwini Water and Sanitation perimeter) where the switchboard is to be assembled shall be specified at the time of ordering.
- With respect to the assembly, eThekwini Water and Sanitation contact person name and number will be given.
- The estimated date of delivery of the switchgear to the address specified in d) above will be given.

B. Tenderers shall note that the complete assembly, testing and commissioning of the switchboard shall comprise:

- The supply of the equipment as per the order in Section F above.
- Delivery to the address in Section F above.
- Complete the assembly of the switchboard and the communication panel and its associated control wiring.

Note 1: The successful Tenderer shall be responsible for the full commissioning of the SCADA Gateway from relay to SCADA Gateway.

Note 2: The successful Tenderer shall ensure that handover is undertaken through a data-pack that includes: 61850 configuration of the relays and scheme, configuration of the switch, configuration of the RTU and supervisory schedules & SCADA Gateway cabinet key.

- d. The installation of the battery charger, its associated batteries as specified in the document
- e. All auxiliary cabling shall be installed above the switchgear in cable racks.
- f. Supply and installation of the cable terminations and connectors as detailed in Section EA14.2.3.
- g. Electrical and mechanical tests and checks shall be performed on the switchboard. Tenderers shall note that the tests and checks shall at least be comprehensive as eThekweni Electricity's tests and checks detailed in the **Pre Commissioning Check Sheet**. Any other tests and checks that are deemed necessary by the successful Tenderer shall be carried out. On completion of the installation and commissioning of the switchgear, the test results and a hand over certificate shall be handed to an official of eThekweni Electricity.

#### EA14.2.13 Documentation

- A. Tenderers shall provide the following documentation with each bid:
  - a. a typical drawing of each type of switchgear panel, showing all relevant dimensions, including the height of the cable gland plate (if any) above the floor level, a floor plan giving the loads imposed on the foundations and detailed methods of mounting;
  - b. a schematic diagram of the primary connections;
  - c. a schematic diagram of the LAN;
  - d. a logical diagram of GOOSE dependencies; and
  - e. Configuration files of the IEDs, switches and RTU.

**NOTE: TENDERERS SHALL SEPARATE INFORMATION (SCADA, PROTECTION, COMMUNICATION, SWITCHGEAR, GENERAL, etc.) INTO ITS OWN FILES FOR THE EASE OF EVALUATION.**

- B. The Tenderer shall submit the following:
  - a. a fully dimensioned general arrangement of the switchboard, illustrating cable boxes and/or cable clamping and cable termination arrangement;
  - b. a schematic diagram of the auxiliary circuits of each type of switchgear panel; and
  - c. a comprehensive copy of operating and maintenance manuals.
- C. Failure to submit such information may preclude further consideration of the bid.
- D. When requested an electronic copy of all the drawings shall be supplied.
- E. An electronic copy of the rating plate, auxiliary equipment and DC registration number shall be supplied with every hand over certificate. The electronic copy shall be in a MICROSOFT EXCEL.
- F. All type test certificates shall be supplied with the bid document in a separate file.

#### EA14.2.14 Training

- A. Training shall be provided as follows:
  - a. Switchgear Operator training priced **per session comprising of 10 candidates**. There will be approximately 5 Sessions required.
  - b. Switchgear Maintenance and Inspection training shall be undertaken by the OEM specialist and be priced per session comprising of 10 candidates. There will be approximately 5 Sessions required.



- c. Protection relay training priced per session comprising 10 candidates. There will be approximately 5 Sessions required.
- d. SCADA training priced per session comprising 10 candidates. There will be approximately 5 Sessions required.

Note: The SCADA training shall include the complete configuration of the RTU and include a site or workshop installation for DNP3 point testing.

- e. Communication equipment training priced per session comprising 10 candidates. There will be approximately 2 Sessions required.
  - The venue shall be provided by successful tenderer
  - All hardware and firmware shall be provided by the successful Tenderer.
  - All training material shall be provided by the successful Tenderer and shall be in the form of a comprehensive booklet as well as a DVD.
  - The content of the training for items A14.2.14/A/ a) and b) shall be in accordance with the manufacturers' requirements and eThekweni Electricity's Safety Regulations.
  - The format of the content for the training for items A14.2.14/A/ a) shall be in accordance with the requirements of eThekweni Electricity's SHERQ and Training Centre. A sample of an existing format can be obtained from the Training Centre.
  - The content for A14.2.14/A/ c) and d) shall cover the engineering of the configuration as well as the setting of the entire protection relay.

#### EA14.2.15 Failure Investigation

Any failure related to the any equipment supplied on this contract within the guarantee period shall be referred to the successful Tenderer. Such failures shall be investigated by the successful Tenderer and a detailed written report be submitted to eThekweni Water and Sanitation within 2 weeks of the successful Tenderer being notified of the failure. The successful Tenderer's portion of the cost of the investigation shall be for the successful Tenderer's account.

#### EA14.2.16 Health, Safety, and Environmental Issues

- Tenderers shall provide the following information in respect of each product offered:
- A list of all materials used in the product, including packaging, and associated chemical data sheets;
- Whether the product poses any health or safety risks to persons handling the product. In addition, if there are risks, the protective gear required to handle the product, e.g. leather gloves, masks, etc.;
- How the product should be disposed at the end of its useful life or in the event of failure of the product.
- Whether any toxic by-products are produced (whether in gaseous, solid or liquid form) in the event of the product being exposed fire or heated to elevated temperatures;
- Any other pertinent and relevant information relating to health, safety, and environmental issues; and
- What percentage of the product can be recycled.
- The Tenderer shall complete the Acceptance of undertaking in terms of the Occupational Health and Safety Act (Act 85 of 1993).
- The successful Tenderer's installation team shall undergo eThekweni Electricity's Safety Rules course and a subsequent test, after which these persons would be deemed Specifically Trained Persons and issued with a contractor's identity card.

### EA15 **MINI-SUBSTATION UNITS**

#### EA15.1 **Quality Assurance**

##### EA15.1.1 Codes and Standards

The Mini-substation Units (MSU) supplied shall comply fully with the applicable SANS specifications as set out in the table below and all equipment shall bear the mark of approval of the South African

Bureau of Standards. The latest issue of the SANS/IEC/ NRS codes will be applicable:

ISO 8501-1: 2007	Preparation of steel substrates before application of paints and related products
ISO 9223: 2012	Corrosion of metals and alloys - Corrosivity of atmospheres: Classification, determination and estimation
NRS 068: 2014	Cable earth fault indicator
SANS 121: 2011	Hot dip galvanized coatings on fabricated iron and steel articles
SANS 164-1: 2018	Plug and socket-outlet systems for household and similar purposes for use in South Africa: Two-pole and earth, 16 A 250 V AC system
SANS 876: 2016	Cable terminations and live conductors within air-filled enclosures (insulation coordination) for rated AC voltages from 7,2 kV up to and including 36 kV
SANS 780: 2009	Distribution transformers
SANS 1029: 2016	Miniature substations for rated AC voltages up to and including 24 kV
SANS 1091: 2012	National colour standards for paint
SANS 1339: 2017	Electric cables - Cross-linked polyethylene (XLPE) insulated electric cables (3,8 kV/6,6 kV to 19 kV/33 kV)
SANS 1874: 2015	Switchgear - Metal enclosed ring main units for rated AC voltages above 1 kV and up to and including 36 kV
SANS 10142-1: 2017	The wiring of premises: Low voltage installations
SANS 60269-2: 2016	Low voltage fuses: Supplementary requirements for fuses for use by authorised persons
SANS 60439-1: 2004	Low voltage switchgear and control gear assemblies: Type tested and partially type tested assemblies
SANS 60529: 2013	Degrees of protection provided by enclosures (IP code)
SANS 60695-11-10: 2004	Fire hazard testing: Test flames - 50 W horizontal and vertical test methods
SANS 60947-3: 2016	Low voltage switchgear and control gear: Switches, disconnectors, switch disconnectors and fuse-combination units
SANS 61243-5: 1997	Live working - Voltage detectors: Voltage detecting systems (VDS)
SANS 61869-2: 2013	Instrument transformers: Additional requirements for current transformers
SANS 62271-200: 2012	High-voltage switchgear and controlgear: AC metal-enclosed switchgear and controlgear for rated voltages above 1 kV and up to and including 52 kV

**EA15.1.2 Manufacturers**

Compliance with the applicable specifications is required, products of the following manufacturers will be acceptable:

- a. The manufacturer must be an ISO9001 certified company. Proof of certification is to be submitted together with the tender document, failing which the tender may be disregarded.
- b. Products must carry the SABS mark or an international certification and approved for use in South Africa.

**EA15.1.3 Installers**

Installers must be certified or registered installers of the manufacturers or their representatives. Manufacturers or their representatives must also have registered offices in South Africa and the local office must carry sufficient stock and spare parts for the project.

**EA15.2 Mini-Substation Units and Ring Main Units**

The equipment shall be designed to operate satisfactorily when subjected to the following operating conditions:

a)	Climate	Humid, heavily salt laden and sub-tropical
b)	Pollution type	Heavy marine, dust and industrial pollution
c)	Altitude	from sea-level to 1 000 m
d)	Ambient temperature	from 0 °C to 50 °C
e)	Maximum relative humidity	99 %
f)	Highest system phase-to-phase voltage	12 kV
g)	System frequency	50 Hz
h)	System neutral earthing	solidly

Tenderers shall acknowledge that the items offered shall perform in the environmental conditions above without having adverse effects to the integrity and operation of such equipment. As such, the items offered shall be protected against corrosion for the stipulated environmental conditions. It shall also be noted that these conditions may be prevalent during storage and during the installed life of the equipment i.e. within the substation building. EThekweni Water and Sanitation has a large installed base of the items listed in this specification and may use current experience when determining performance to the above environmental conditions for the same type of equipment offered.

**EA15.2.1 Common Requirements of Mini-substation Units and Ring Main Units (RMU)**

- a. The ring main units shall be manufactured from either Aluzinc, stainless steel or 3CR12 steel. Other material may be accepted at the discretion of the Project Engineer. The ring main units shall be installed within the eThekweni area of supply and shall thus be protected from corrosion for the conditions as specified in Section EA15.2. All items shall be supplied with a minimum 5-year warranty against corrosion and a 20-year warranty against SF6 gas leaks (where SF6 units are offered).
- b. Outdoor ring main units shall be housed within an enclosure and fitted onto a concrete plinth. All enclosures shall be manufactured of 3CR12 steel. All nuts, bolts, washers and hinges used in the assembly of the housing and for mounting onto the concrete plinth shall be manufactured with marine grade stainless steel (316). Mini substations shall be supplied on a concrete plinth.

- c. All enclosures shall be protected from corrosion taking into consideration the environmental conditions as in Section EA15.2, and as defined in ISO 9223 for C5 environmental conditions. Details of the coating system used shall be submitted with the bid document, together with proof of compliance to satisfactory performance in C5 environments. All items shall be supplied with a minimum 5-year warranty against corrosion.
- d. The colour of the mini-substation and ring main unit enclosures shall be an acceptable match to colour C37 (light stone) of SANS 1091: 2012.
- e. Transformers shall be protected from corrosion in accordance with SANS 780 for transformers used in corrosive environments.
- f. Door contacts shall be provided for all doors on enclosures and wired to terminal blocks. These contacts shall be integrated into the Intelligent Electronic Device (IED) or Remote Terminal Unit (RTU) for the items fitted with these devices to allow signals to be transmitted to eThekweni Water and Sanitation's Control Centre.
- g. All enclosure access doors shall be secured with three-point locking mechanisms. No allen cap screws shall be fitted. The doors shall be capable of being padlocked to prevent unauthorised access. A padlock protection facility in accordance with SANS 1029 shall be provided, however, the door handle and padlock protection facility shall accommodate a 50 mm high security padlock with a shackle diameter of 10 mm. The lock used by eThekweni Water and Sanitation is the Union SH50SO high security padlock.
- h. The left door of the LV compartment on the mini-substation enclosure, and the left door of the ring main unit enclosure (for outdoor ring main units) shall be drilled with 4 x 5 mm holes prior to coating of the doors. The holes shall be used by eThekweni Water and Sanitation to pop rivet an A4 sized label to the door. A template of this label and confirmation of the mounting position shall be supplied to the successful Tenderers at time of award. These holes shall be sealed with plastic weatherproof studs/grommets.

#### EA15.2.2 Specific Requirements of Mini-Substations

The mini-substations shall comply fully with SANS 1029, except where amended by this specification.

##### A. Bases

Steel bases shall be hot dip galvanised in accordance with the relevant requirements of SANS 121, be coated with black epoxy tar paint and shall extend the full length of the mini-substation.

##### B. Enclosure

The enclosure of the mini-substation shall be manufactured of 3CR12 steel. The colour of the minisubstation shall be an acceptable match to colour C37 (light stone) of SANS 1091: 2012. The roof shall be of the removable type. It shall only be possible to lift the complete mini-substation with the roof installed.

##### C. Type and dimensions

The mini-substation shall be of a unitary design and comply with Type B mini-substations in accordance with SANS 1029: 2016. To this effect, the Type B mini-substation base and plinth dimensions shall be taken into account when designing the mini-substation.

##### D. Internal arc classification (IAC)

The internal arc classification of the mini-substation shall be IAC-AB FLR 20 kA, 0,5 s in accordance with SANS 1029.

##### E. Transformer

- a. All transformers shall be manufactured in accordance with SANS 780.
- b. All transformers shall be provided with Type C bushings on the medium voltage (MV) side and single phase porcelain bushings on the low voltage (LV) side; these bushings shall be clamped as called for in SANS 780.

- c. Transformer terminals shall be suited for the acceptance of both aluminium and copper conductors. To this effect, bushing terminals shall be tinned or silver plated, etc.
- d. Connections between the transformer and the cable terminal in the MV compartment shall be made by means of single-core screened cross-linked polyethylene copper cables in accordance with SANS 1339 for the rated voltage of the connected equipment and having a conductor of minimum cross-sectional area rated for the transformer. The connectors shall comply with SANS 876: 2016 for Type 4 connectors. These connectors shall be fitted on both the transformer as well as the switchgear side of the cable.
- e. Dual ratio
  - Where mini-substations with dual ratio transformers are specified, the MV windings shall be connected in parallel for 6,6 kV service and in series for 11 kV service. The changeover from 6,6 kV to 11 kV shall be carried out by means of a suitable changeover switch. The changeover switch control handle shall be capable of being locked in either position and the selected arrangement of the winding shall be clearly indicated. It shall not be possible for the switch to be left in a position other than where the winding is connected for either a 6,6 kV or 11 kV supply. A cover shall be fitted over the switch handle clearly marked "DUAL RATIO CHANGEOVER SWITCH" in red lettering.
  - Mini-substations with dual ratio transformers shall carry a warning notice fixed to the transformer in a prominent position, bearing the following legend coloured in red on a white background:

WARNING

6,6/11 kV DUAL RATIO TRANSFORMER. CHECK THAT THE TRANSFORMER  
WINDINGS ARE CONNECTED CORRECTLY

- In addition to the above, one reversible brass tag engraved or stamped "CONNECTED FOR 11 kV" on one side and "CONNECTED FOR 6,6 kV" on the other, shall be bolted adjacent to the rating plate where it can be easily observed.
- f. Linear tap switches shall not be accepted. The tap switch shall have two O-ring gaskets.
- g. Transformers shall have a tapping range of -5 %, -2,5 %, 0 %, +2,5 %, +5 %, achieved by means of an off-circuit tapping switch.
- h. The operation of the off-circuit tapping switch shall be such that by turning the handle clockwise, the tap position number is increased.
- i. If corrugated cooling radiators are utilised in the design of the transformer, then this design is to ensure that the cooling radiators are adequately protected against mechanical damage as well as corrosion.
- j. The transformer shall be fitted with a bolted main tank lid.
- k. The transformer shall be fitted with a prismatic oil gauge mounted onto the tank. Alternative oil gauges shall be subject to the approval of the Project Engineer .
- l. The oil gauge and tap switch depicting the respective tap positions shall be easily visible and readily accessible with the transformer door of the mini-substation open.
- m. A suitable barrier in accordance with SANS 1029 shall be fitted over the LV terminations of the transformer.

**F. Ring main units and ring main unit compartment**

- a. The ring main unit and ring main unit compartment of the mini-substation shall comply with the requirements of Section EA15.2.3 of this specification.

- b. The centre switch function of the ring main unit shall be used for connection onto the transformer. This shall be clearly labelled (black writing on a white background) with the words 'LOCAL TRANSFORMER'.
- c. Ring main units fitted into mini-substations shall be fitted with one earth fault indicator (EFI). The earth fault current sensor shall comply with clause 6.2.5 of SANS 1029: 2016.

G. Low voltage (LV) switchboard assembly

d. General

The LV assembly shall comprise of one floor mounting frame supporting:

- a. 1 x set of 800 A, triple pole and half-size neutral busbars (**Aluminium**);
- b. 1 x earth bar (**Aluminium**) extending the full length of the frame;
- c. 1 x incoming 800 A switch disconnector;
- d. 1 x instrument panel
- e. 6 x blanking off plates for outgoing circuits;

LV assemblies shall comply with SANS 60439-1.

All assemblies shall be fitted with removable devices at each end and, as near as possible to the balance line, to facilitate handling during transport.

The incoming switch disconnector shall be positioned as near as practical to the right of the LV assembly. Additional outgoing distributor units will be mounted by eThekweni Water and Sanitation side-by-side. The spacing between the centres of outgoing distributor units shall be  $120 \text{ mm} \pm 5 \text{ mm}$ .

LV assemblies shall be so designed to ensure that thermal interaction does not unduly affect the performance of any of the components.

Insulating materials shall be of high quality, flame retardant and as non-hygroscopic and resistant to tracking as good manufacturing techniques permit. The main current carrying components shall be electro-tin or electro-silver plated. All fasteners, nuts, bolts etc. shall be hot-dipped galvanized and shall have corrosion-proof locking features.

All parts of the LV assembly shall, as far as practicable, be readily accessible and replaceable without excessive dismantling. All parts of equal size and rating shall be inter-changeable. The general design shall be such that the number of joints shall be kept to a minimum. Storage facilities shall be provided on the mounting frame for all loose devices, e.g. operating handles, padlocking devices.

The minimum rated operational/insulation voltage ( $U_e/U_i$ ) shall be 400 V/440 V respectively. The rated impulse withstand voltage shall be 8 kV.

The complete LV switchboard assembly shall provide an equivalent protection to IPXXB and it shall not be possible to come into contact with any exposed current carrying components.

b. Mounting frame

The mounting frame shall be fabricated from mild steel and adequately protected against eThekweni Municipality's highly corrosive environment as specified in A15.2, be of a robust construction and provide adequate support for the incoming switch disconnector, busbars and outgoing distributor units. Material other than mild steel may be considered at the sole discretion of the Project Engineer, if it is deemed to satisfy all other requirements above.

The LV assembly shall readily facilitate the termination of cables from the front.

A channel (Unistrut or equal) shall be provided to support outgoing cables. The channel shall be positioned approximately 50 mm above ground, towards the rear and extend the full length of the assembly. There shall be a minimum distance of 450 mm between the centre of the channel and cable terminals of outgoing distributor units.

## c. Busbars

Busbars shall be three-phase, neutral and earth, and, be manufactured from Aluminum. The busbars shall be tinned for heavy duty applications.

The neutral bar shall be rated at not less than half that of the phase busbar rating.

The earth bar shall be capable of carrying the rated short time withstand current corresponding to that specified in clause 4.7.8 of this specification and as determined by SANS 60439-1.

Phase and neutral busbars shall be situated at the rear of the equipment and positioned vertically above each other and in a sequence, red, yellow, blue and neutral from top to bottom. The earth bar shall be mounted in the lower part of the assembly; behind the outgoing cables and immediately above the channel supporting the cable cleats. The spacing between centres from red to white shall be 185 mm and from white to blue shall be 185 mm.

Phase busbars shall be colour identified in sequence from top to bottom, red, yellow, and blue. The neutral busbar shall be colour identified black and the earth busbar shall be unmarked.

The neutral busbar shall be insulated from the framework and include one terminal for each, incoming circuit and outgoing distributor unit.

The earth bar shall be bolted to the frame and include an earth M12 terminal projecting through the right hand end of the frame. The earth terminal shall be suitable for connecting to an external earth bonding conductor and be complete with a corrosion proof flat washer, lock washer and nut.

A removable bolted link shall connect the neutral busbar to the earth bar.

## d. Incoming switch disconnecter

The incoming circuit shall comprise of an 800 A switch disconnecter and shall comply with SANS 60947-3.

Switch disconnectors shall be of the three-phase, manually dependent, pole operated type, with each phase independently operable. Phases of switch disconnecter units shall be arranged vertically above each other in sequence: red, yellow and blue; from top to bottom.

The switch disconnecter contacts shall include a means of contact tightening designed to obviate slackening when subject to vibration. Good contact shall not depend on the natural spring of the contacts. The contact-tightening device shall be operated by the insulated switch disconnecter operating pole. Interlocks shall be provided to ensure the operating pole cannot be removed unless the switch disconnecter is fully closed, contact pressure applied and locked closed, or, fully open, isolated and locked open.

Exposed metal on the operating pole shall not become live.

Switch disconnectors shall comply with the requirements of SANS IEC 60947-3 and have a single- phase performance capability as detailed in the Table below.

Switch disconnecter rating	800 A
General performance characteristics ( $U_e = 230$ V)	AC-21B
Operational performance capability ( $U_e = 230$ V)	AC-21B
Short-circuit performance capability ( $U_e = 230$ V)*	18 kA for 0,5 s

\*Three-phase short time withstand current capability requirements of this specification must be complied with when the LV assembly is tested as a complete assembly in accordance with SANS 60439-1.

Switch disconnectors shall include a 'visible break' facility.

Labels shall clearly identify 'Open' and 'Closed' positions of switch disconnectors.

In addition to the interlocks associated with the operating pole, switch disconnectors shall be capable of being padlocked in the open position. Where appropriate this may involve the use of a supplementary insulated device.

Access shall be provided for the use of voltage test probes. These shall be able to make contact with load and line contacts of an open switch disconnector.

Each phase of the incoming circuit of the LV assembly shall be equipped with a current transformer. The current transformers shall be resin encapsulated and be located within the incoming switch disconnector. Current transformers shall be of an 800/5 ratio, class 5 and be suitable for a burden of 5 VA.

The incoming neutral cables shall connect directly to the neutral busbar. Incoming cable terminals located behind the busbars or behind outgoing distributor cables are not acceptable. Incoming circuit cable terminal bolts shall be M12 stainless steel. A flat washer and lock washer shall be provided for each cable terminal fixing.

All interconnecting cables between the LV busbar of the switchboard and LV bushings of the transformer shall be flexible aluminium conductor. The conductor ratings shall match the rating of the transformer, temperature rise of the enclosure, etc. Calculations shall be submitted with the bid document to confirm this match.

e. Outgoing switch fuse disconnectors

The rated normal current of an outgoing switch fuse disconnector shall be 400 A.

Outgoing switch fuse disconnectors shall be of the manually dependent, three-phase fuse switch disconnector type with each phase independently operable. Phases of outgoing switch fuse disconnectors shall be arranged vertically above each other in sequence: red, yellow and blue; from top to bottom. All fuse switch disconnectors shall comply with SANS 60947-3.

All fuse switch disconnectors shall be of the double opening type with switching effected by movement of the fuse carrier.

Fuse switch disconnectors when tested in single-phase mode shall comply with test sequences I, II, and IV of SANS 60947-3: 2016. Their rated single-phase operational current and voltage shall be 400 A and 400 V, respectively. Utilisation category shall be AC-22B and, the rated single-phase fused short circuit current shall be 50 kA at 400 V. In addition the outgoing distributor units shall comply with the requirements of test sequence V of SANS 60947-3: 2016 for three-phase operation.

Access shall be provided for the use of voltage test probes. The test probes shall be able to make contact with the top and bottom fuse link terminals when fuse carriers are installed and, the top and bottom contacts when the fuse carrier is removed.

One set of three fuse carriers shall be provided with each outgoing switch fuse disconnector supplied.

Each outgoing switch fuse disconnector unit shall be suitable for the connection of 1 x 4-core 240 mm<sup>2</sup>, stranded copper or aluminium conductor cable with polymeric insulation. Phase cable terminals shall be located at the bottom of each outgoing distributor unit. Cable terminals shall be dual marked L1, L2 and L3 respectively. Phase cable terminals of each outgoing switch fuse disconnector shall be shrouded using a removable transparent terminal cover. Cable terminal fixings shall be M10.

Outgoing cables shall be terminated using torque sheer lugs.

Provision shall be made on each outgoing switch fuse disconnector to affix a safety padlock that prevents the three fuse carriers being installed. This may require the use of a supplementary insulated device. It shall be possible to install a safety padlock whilst the LV assembly is live and in normal service.



f. Current transformers

All current transformers shall comply with SANS 61869-2.

g. Instrument panel

Each LV assembly shall incorporate an instrument panel equipped with:

- Three insulated thermal maximum demand indicators. These maximum demand indicators shall monitor the incoming current to the LV assembly and be suitable for use with current transformers of ratio 800/5, scaled 0 A - 800 A and have a 15 minute time delay.
- One switched 16 A, three pin, (single-phase, neutral and earth) auxiliary socket outlet in accordance with SANS 164-1.
- One fuse for protection of the auxiliary socket outlet. This shall be fitted with a 16 A Size A1 fuse link in accordance with SANS 60269-2.
- ES14 brass fitting (with 11 W CFL lamp) wired to a single pole switch in accordance with SANS 10142-1. All terminal connections shall be equivalent to IP2X and it shall not be possible to come into contact with any exposed wiring.
- One Intelligent Electronic Device (IED) which shall measure the LV current and voltage and shall be capable of being integrated into eThekweni Water and Sanitation's SCADA network. The communication protocol between the modem and the master station is DNP3 over TCP/IP. The modem shall not be supplied, however adequate space shall be allocated for the mounting of the modem of dimensions 300 mm (width) × 250 mm (height) × 100 mm (depth). The device shall have at least 4 inputs and 4 outputs. These shall be wired to integrate the following:
  - Door open/close switches (all doors per unit to be paralleled into one input);
  - EFI operation; and
  - The others shall be spares.

The mounting of the device shall be such that it is easily accessible from the front of the LV compartment. All wiring shall be connected via spring loaded terminals to the IED. All wiring shall be clearly marked for easy identification.

h. Short circuit rating

The short circuit rating of the LV assembly shall be 18,0 kA for 0,5 s. If no test has been conducted with the use of aluminium busbars, then this shall be verified by means of calculation.

i. Creepage and clearances

Creepage and clearance distances shall not be less than 19 mm between conductors and 19 mm from conductors to earth. Where these clearances cannot be achieved, or where special risk exists, adequate solid insulation shall be provided.

j. Personnel protection

When installed, the LV switchboard assembly shall provide protection in accordance with IP XXB of SANS 60529: 2013. Additionally, operators shall be provided with protection in accordance with IP XXB under all normal operating conditions from the following:

- The switching circuits;
- Incoming switch disconnectors in the 'Open', 'Closed' and transitional states;
- Outgoing fuse switch disconnectors in the 'Open', 'Closed' and transitional states (fitted by eThekweni Water and Sanitation);
- Fuse carriers in the 'ON', 'OFF' and removed states;
- Changing of fuse links; and
- Cabling of one outgoing switch fuse disconnector with the remainder live and in service.

The points above shall assume that there is the possibility of a back feed or alternative supply present and that the protection is applicable under these conditions.

k. Rating plate

An external rating plate shall be fixed to each LV switchboard assembly detailing the following information:

- Serial number which shall be unique to each assembly;
- Year of manufacture;
- Normal current rating of the phase busbar;
- Gross weight, when fully equipped (kg); and
- Manufacturer's name and reference number.

l. Circuit labels

Each incoming switch disconnecter unit shall be provided with a circuit label.

The circuit labels shall be 75 mm x 50 mm and made of insulating material. This label shall be mounted at the top of each circuit and securely fitted without the use of screws. It shall be possible to slot the label into position and remove it from the front of the assembly. The labels shall be suitable for engraving by the eThekweni Water and Sanitation to show black letters on a white background.

m. Padlocking facilities

Padlocking facilities shall be provided for the incoming switch disconnecter in the open position and for the outgoing distributor units with the fuse carriers removed.

When a supplementary padlocking device is required to lock outgoing distributor units, one device shall be supplied with each LV assembly. Should a separate device be required for padlocking the switch disconnecter in the OFF position, one such device shall be provided with each switch disconnecter.

Safety padlocks have a body size of up to 40 mm x 40 mm and, an 8 mm diameter shackle having a clear inside width of 20 mm, with an inside length of between 16 mm and 30 mm. The hole provided for the shackle shall not be less than 8 mm diameter.

n. Type tests

Evidence (test reports and test certificates) shall be submitted with bid documents to confirm that a complete LV assembly has satisfactorily completed the required type tests. Testing shall be undertaken in a laboratory that is ILAC accredited.

o. Short-circuit withstand strength

Short-circuit withstand tests shall be undertaken in accordance with the requirements of clause 4.7.8 of this specification and clause 8.2.3 of SANS 60439-1: 2004. Outgoing switch fuse disconnectors shall be fitted with 400 A fuse links for the tests.

p. Temperature rise

Temperature rise tests shall be carried out in accordance with sub-clause 8.2.1 of SANS 60439-1: 2004 noting that:

- The temporary incoming and outgoing test connection shall be a cable of the type and size detailed in this specification, namely:
  - incoming circuit, two cables per phase of 185 mm<sup>2</sup> stranded copper conductor cable; and
  - fused distributor units, one, 240 mm<sup>2</sup> copper/aluminium conductor cable per phase;
- Outgoing switch fuse disconnectors shall be fitted with 400 A fuse links; and
- The test shall be undertaken with the incoming circuit carrying its rated current. Sufficient adjacent outgoing distributor units as the incoming current will permit shall be loaded to their rated current multiplied by a diversity factor of 0,8 (320 A).

If no test has been conducted with the use of aluminium busbars, then this shall be verified by means of calculation and this information shall be submitted with the bid documents.

q. Dielectric test

The requirements of clause 8.2.2 of SANS 60439-1: 2004 shall apply noting that, the power frequency dielectric test (see sub-clause 8.2.2.4) shall be undertaken with the specified voltage maintained for one minute.

r. Flammability tests

Representative specimens of each type of insulating material used shall be subjected to a flammability test in accordance with Test Method A – horizontal burning test of SANS 60695-11-10: 2004. Compliance is checked by inspection that each set of specimens can be classified to Category HB40 criteria a) or b) in accordance with clause 8.4 of SANS 60695-11-10: 2004.

s. Routine tests

Clause 8.3 of SANS 60439-1: 2004 shall apply.

### EA15.2.3 Requirements of Ring Main Units

#### A. General

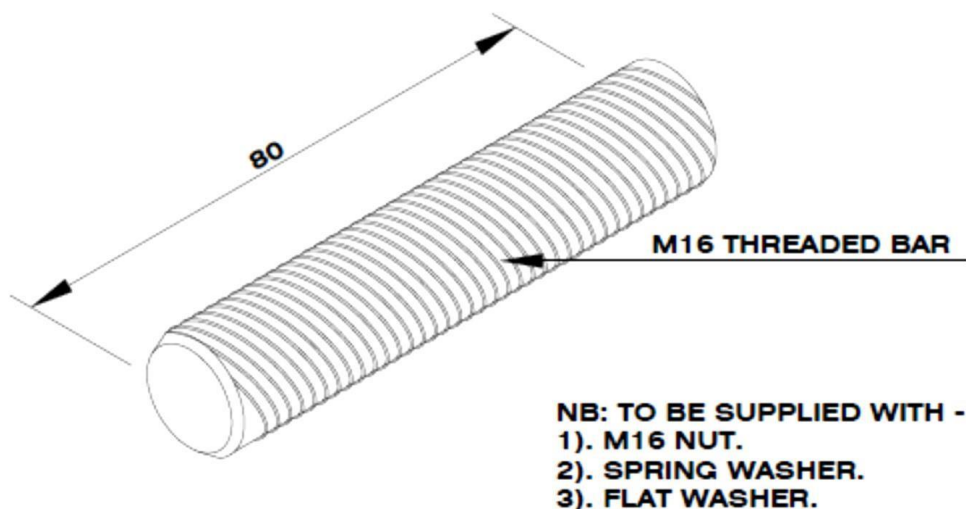
- a. All ring main units shall comply fully with the requirements of SANS 1874, SANS 876 and the requirements of this specification.
- b. Ring main units shall be of the maintenance free type.
- c. The three MV switches of the ring main unit will be of circuit breaker type.
- d. All switch functions of the ring main unit shall be operable from the front of the ring main unit.
- e. All switch functions of the ring main unit shall be fitted with an integral earthing switch and cable test facility. Access to the cable test facility and cable box shall only be possible when the associated earth switch is in the earth position. Each switch disconnecter and earth switch shall be capable of being locked in the OFF and EARTH positions.
- f. All switch functions shall be provided with cable boxes in accordance with SANS 876: 2016, suitable for air terminations. The distance between the centre line of the bushings and the cable support clamp shall be at least 800 mm. This may be achieved by installing a raising base to the ring main unit.
- g. The type of cables used by eThekweni Water and Sanitation is PILC belted and XLPE cables. Due to eThekweni's use of PILC belted cable, no ring type current transformers will be accepted in the cable compartment for installation around cables.
- h. A clamping device shall be provided to support the cables, noting that the cables being used are 3-core PILC belted or XLPE cables. The clamping device shall be approved by the Project Engineer .
- i. All bushings shall comply with clause 4.8.4 of SANS 1874: 2015.
- j. Ring main units offered for outdoor use shall be fitted in a 3CR12 enclosure and firmly mounted onto a concrete plinth. Lifting lugs shall be designed such that it carries the full weight (enclosure, ring main unit and concrete plinth).
- k. The enclosure shall comply fully with sub-clause 4.14 of SANS 1874: 2015 except where amended by this specification.
- l. The concrete plinth for outdoor ring main units shall have a minimum strength of 25 MPa, 7 days. It shall be designed to allow for bottom entry of the medium voltage power cables into each power cable compartment of the ring main unit. It shall also allow for one 50 mm hole for entry of a low voltage cable which shall align with the LV supply connector block. Tenderers shall supply all layout and engineering specification drawings with the bid documents. The drawings shall be to the approval of the Project Engineer .
- m. The following shall be installed to the inside right top of the ring main unit compartment:

- One switched 16 A, three pin, (single-phase, neutral and earth) auxiliary socket outlet in accordance with SANS 164-1;
- One fuse for protection of the auxiliary socket outlet. This shall be fitted with a 16 A Size A1 fuse link in accordance with SANS 60269-2; and
- One ES14 brass fitting (with 11 W CFL lamp) wired to a single pole switch in accordance with SANS 10142-1. All terminal connections shall be equivalent to IP2X and it shall not be possible to come into contact with any exposed wiring.

The equipment above shall be wired to the top end of an LV supply connector block with spring loaded terminals. These terminals shall be clearly marked live, neutral and earth. The connector block shall accept a 16 mm cable.

Further provision shall be made to gland off a cable below these terminals. The gland hole size shall be a diameter of 25 mm. This shall align to the 50 mm entry hole in the concrete plinth. Note that this requirement is not applicable for mini-substations as the LV supply on the mini-substation is obtained from the LV switchboard.

- n. Earth fault indicators (EFIs) shall be fitted to all isolator switch functions on stand-alone indoor and outdoor ring main units. Ring main units fitted into mini-substations (items 1 and 2) shall be fitted with one EFI. The earth fault current sensor shall comply with clause 6.2.5 of SANS 1029: 2016. Each earth fault indicator shall comply with clause 5.4 of this specification.
- o. A voltage detection system (VDS) in accordance with SANS 61243-5 shall be fitted to each switch function. The VDS system shall be of the HR type. Tenderers are to note that a VDS system comprises of a test point as well as cable live indication.
- p. All ring main units shall be fitted with M16 brass studs on all cable bushings. These studs shall be in accordance to Figure 1 below and shall be to the approval of the Project Engineer . Each stud shall be supplied with a brass spring washer, flat washer and M16 nut.



**Figure 1 – M16 brass stud**

- q. Switch functions shall be padlockable to prevent inadvertent operation of the unit after isolating and earthing. The locking point shall be durable, robust and of a strong material such as steel or aluminium, and shall be to the approval of the Project Engineer .

- r. Ring main units installed in brick building substations shall have dimensions compatible to the existing substations. As such, the ring main unit shall comfortably fit through a door opening of 1 000 mm x 2 400 mm. The minimum distance between the back wall and the front of the cable trench is 700 mm with a cable trench width of 600 mm. The footprint of the ring main unit shall cater for these dimensions for indoor installations.
- s. Where motors are fitted to the ring main unit, the manual operation of the ring main unit shall be independent of the motor and charging devices. No external motors shall be fitted to the ring main units.
- t. The cable box shall be interlocked based and not tools based. The internal arc requirements shall not be dependent on the use of removable fasteners on the cable box which could be removed by an operator during installation or maintenance work and accidentally omitted thereby compromising the internal arc requirements.

**B. Internal arc classification (IAC)**

The switchgear shall be tested in accordance with SANS 62271-200, with the following additional requirements:

- a. All power compartments shall be tested.
- b. All panels shall be tested with the correct size current transformers, if applicable.
- c. Where power cables impede the venting of the compartment, they shall be installed for testing purposes.
- d. The testing conditions shall be represented as close as possible to those of normal service. They shall be represented by a floor, the ceiling above the top of the power compartments, lateral and rear walls. The clearance of the room simulation shall be in accordance with clause AA.2.2 of SANS 62271-200: 2012.
- e. The internal arc classification of the ring main units shall be in accordance to clause 4.3.14 of SANS 1874: 2015 i.e.:
  - Indoor units shall be IAC AFL 20 kA, 0,5 s (restricted accessibility to authorised personnel only for the front and lateral sides of the ring main unit); and
  - Outdoor units shall be IAC A-B FLR 20 kA, 0,5 s (restricted accessibility to authorised personnel only for the front of the ring main unit and unrestricted accessibility for the front, lateral and rear sides of the ring main unit assembly).

**C. Cable test facility requirements**

- a. Integral cable test facilities shall be provided on the front of the switch panel and independent of the cable termination enclosure.
- b. The cable test facilities provided shall be able to connect cable test equipment (e.g. voltage testing or fault locating equipment) to the cable through the cable test facility without compromising the IAC of the ring main unit.
- c. Each cable test facility shall be interlocked with its associated earth switch to ensure that the test terminals of the cable test facility are not accessible when the cable is energised. Access to the test terminals of the cable test facility shall only be possible when the associated earth switch is in the EARTH position.
- d. Where removable short-circuiting connections are provided for cable earthing (e.g. a removable star point connection), the re-instatement of these connections following cable testing shall not require the use of tools and/or the application of specific torque settings. This implies that no bolted connections are accepted. It shall not be possible to close the cable test facility if the short-circuit connections have not been re-instated. It shall not be possible to physically remove the shortcircuiting connections from the switchgear.
- e. Where test probes are required in order to carry out cable testing, a complete set of three test probes shall be supplied with each switch function and securely mounted at a readily

accessible location on the inside of the access cover. If this is not possible then other means may be implemented so that access to the test probes are only possible when the cable test facility is accessed. This shall be to the approval of the Project Engineer .

- f. The cable test facility shall be padlockable in the closed position.

D. Earth fault indicators (EFIs)

a. General

EFIs offered shall comply with the technical requirements detailed in NRS 068, except where such requirements are modified in this specification.

The EFI shall comprise the following:

- an earth fault current sensor;
- an indicating and control unit (ICU);
- a remote indication unit (RIU) for outdoor units;
- leads to electrically connect the earth fault current sensor and RIU to the ICU; and
- a lead to connect the ICU to a 230 V, 50 Hz auxiliary supply.

The individual components of the EFI shall be supplied fully wired as a complete unit.

The installation of the EFI shall not require for the ICU to be opened. This is to eliminate the risk of access to the components of the ICU. It is preferred that access to the connection terminals for the RIU and potential free contact be within a separate compartment within the ICU.

The EFI shall operate and provide permanent indication for an earth fault current having a minimum value of 50 A and a minimum duration of 50 ms (2,5 cycles), and shall be capable of withstanding high earth fault currents for at least 1,5 s. The EFI shall not operate for current spikes or magnetising inrush currents.

The EFI shall automatically reset from a 230 V, 50 Hz, auxiliary supply. Manually resetting EFIs shall not be accepted. The EFI shall reset within 10 seconds of restoration of supply.

The ICU of the EFI shall be housed in a weatherproof case and shall be subjected to the appropriate tests in SANS 60529 for a degree of protection of IP 65.

All bolts, nuts and washers of size M8 and smaller and all exposed metal parts shall be manufactured of stainless steel of grade 304, 316 or 317.

Where different metals and alloys are used in the design, the design shall be such that there shall be no contact between dissimilar metals and alloys unless these metals and alloys are galvanically compatible or unless suitable steps have been taken to prevent galvanic corrosion.

The EFI shall provide a clear indication of an earth fault by means of a mechanical flag indication on the ICU, and by means of a flashing light-emitting diode (LED) on the RIU.

b. Earth fault current sensor

The earth fault current sensor shall be a split core type core-balance current transformer (CT) and shall be fully encapsulated and corrosion resistant.

The earth fault sensor shall accommodate:

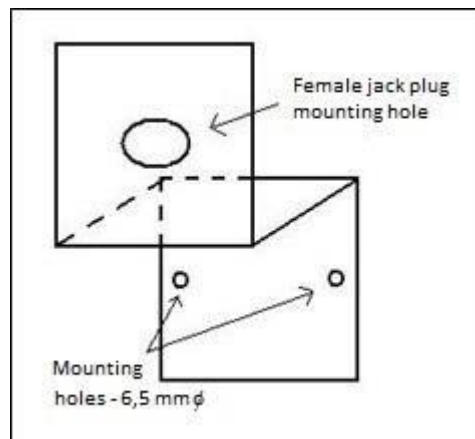
- one 11 kV, three-phase cable having an outside diameter ranging from 32 mm (35 mm<sup>2</sup>) to

- 90 mm (300 mm<sup>2</sup>); and
- one 35 mm<sup>2</sup> PVC insulated earth conductor; and
- five 2,5 mm<sup>2</sup> PVC insulated conductors (used for injecting test current).

The earth fault current sensor shall be provided with a suitable non-conductive, adjustable fixing device (such as a suitably sized cable tie) to attach the sensor to the cable in a suitable position. The fixing device shall be adjustable between 40 mm and 100 mm diameter.

The earth fault current sensor shall be supplied with five turns of 2,5 mm<sup>2</sup> PVC insulated conductor closely wrapped around and fixed into place with insulation tape. The conductor shall be continuous and have a lead length of two metres and then neatly terminated into the female end of a two pole, 6,35 mm jack plug. Current shall be injected via this jack plug to positively test the entire circuit including CT and wiring.

The female jack plug shall be mounted onto a 3 mm thick aluminium bracket. The bracket shall be similar to Figure 2 below.



**Figure 2 – Mounting bracket for EFI jack plug**

The bracket shall be neatly mounted to the right hand side of the ring main unit (for indoor units), or to the inside right hand side of the MV compartment (for outdoor units).

c. Indicating and control unit (ICU)

The indication on the ICU shall be by means of a mechanical flag and shall easily be visible from at least five meters in daylight.

The ICU shall be designed for panel mounting and shall have one 20 mm long stainless steel stud for mounting purposes. The stud shall be fitted with one stainless steel nut and washer. Alternative fixing systems may also be considered. The mounting of the ICU shall not require the unit to be opened.

The ICU shall have one potential free contact that closes when the unit senses a fault and operates. This contact shall be wired to a terminal block for all ring main units.

For mini-substations, the output shall be wired via the terminal block to the IED as specified.

d. Remote indication unit (RIU) for outdoor units and mini-substations

The EFIs fitted to outdoor units and mini-substations shall be provided with a RIU with indication achieved via a flashing LED. The unit shall be designed such that a minimum of 8 hours of LED indication is achieved.

The RIU shall be such that it is mountable on a flat steel plate of up to 5 mm thick, and shall be vandal-proof and weatherproof for outdoor mounting with an IP 65 degree of protection in accordance with SANS 60529.

The RIU housing shall be M12 and corrosion resistant. All nuts and washers supplied for mounting purposes shall also be corrosion resistant.

The RIU shall be mounted on the outside of the enclosure in such a manner that it can be clearly viewed from the front of the enclosure without having to open the enclosure. The unit shall be visible from at least 25 m during daylight and be vandal-proof.

e. Leads

The leads shall be double insulated with an over-sheath to prevent mechanical damage.

The lead that electrically connects the earth fault sensor to the ICU, and the lead that electrically connects the ICU to the 230 V, 50 Hz, auxiliary supply shall each have a minimum length of two metres.

E. Additional Requirements for 'Smart Ready' Ring Main Units (Applicable to only Outdoor Units)

- a. Where 'Smart Ready' ring main units are specified, these units shall be fitted with all auxiliary equipment required for automation (control and indication) of the ring main unit, with the only omission being the remote terminal unit itself. As such, all position switches, motor mechanisms, current transformers and all other associated equipment shall be completely fitted to the ring main unit and wired to the female end of a plug connector(s) which shall be located/mounted in the remote terminal unit enclosure.
- b. A remote terminal unit enclosure shall be securely fitted onto the left side of the ring main unit enclosure, shall be side facing and elevated off the ground level. The enclosure shall have suitable space and mounting arrangements to accommodate the remote terminal unit with associated wiring and equipment, as well as have an additional 350 mm height across the length of the RTU enclosure to accommodate for the modem and communication equipment. A pre-cut hole of 20 mm diameter for the antenna cabling shall be supplied and sealed with a weatherproof grommet on the top of the remote terminal unit enclosure.
- c. The remote terminal unit used shall be in accordance with section EA15.2.4 of this specification. In addition, all wiring from the remote terminal unit shall terminate into the male end of a plug connector(s) of section **Error! Reference source not found.** to achieve full functionality of the remote terminal unit and ring main unit.
- d. No additional wiring or modifications to the 'Smart Ready' ring main units shall be required. It shall be possible to connect the remote terminal unit of section **Error! Reference source not found.** to the ring main unit via the plug connector(s) to achieve full functionality.
- e. The LV supply to the remote terminal unit shall be via the ring main unit enclosure. The LV supply shall be wired to a terminal block within the RTU enclosure.
- f. All wiring schematics used shall be supplied with the bid documents.
- g. Manual operation of 'Smart Ready' ring main units shall not require the winding/charging of the opening/closing mechanism via the handle for operation.



F. Additional requirements for ring main units fitted with remote terminal units (applicable to only indoor units)

- a. Where ring main units are specified to be fitted with remote terminal units, the remote terminal unit used shall be in accordance to section EA15.2.4 of this specification.
- b. The remote terminal unit shall be fitted to the left side of the ring main unit and shall be front facing.
- c. All wiring between the ring main unit and remote terminal unit shall be via a plug connector(s) to achieve full functionality of the remote terminal unit and ring main unit.
- d. The LV supply to the remote terminal unit shall be wired from the top end of an LV supply connector block with spring-loaded terminals mounted to the left side of the ring main unit below the remote terminal unit. These terminals shall be clearly marked live, neutral and earth. Further provision shall be made to clamp the substation LV supply cable below these terminals.
- e. Manual operation of ring main units with remote terminal units shall not require the winding/charging of the opening/closing mechanism via the handle for operation.

EA15.2.4 Requirements of Remote Terminal Units (RTUS)

'Smart Ready' ring main units and ring main units fitted with RTUs (as specified) shall be integrated into an automation system. This shall be achieved via the RTU. The RTU and associated components shall be housed within a lockable cabinet. Operation functions via the RTU shall be possible without unlocking the cabinet. Access to the components of the RTU shall only be possible with the RTU cabinet unlocked.

The automation and monitoring functions shall achieve the following:

- Short circuit/earth fault indication for remote and local reading;
- Remote switch position indication;
- Remote opening/closing of switches;
- Remote measurement of current;
- Local/remote switch;
- A.c. fail alarm;
- Battery charger faulty alarm;
- RTU door open alarm; and
- Ring main unit door open alarm (outdoor units).

The RTU shall be fitted with a battery and charger unit compatible for its operation/duty. A separate a.c. circuit breaker shall be provided to isolate a.c. supply to the RTU and modem. A d.c. supply of 12-32 V, 1,5 A shall be provided to power the modem and shall be clearly labelled.

The RTU shall be able to communicate via DNP3.0 over TCP/IP. The bidder shall provide a DNP3.0 over Ethernet TCP/IP certificate of compliance issued by an independent authority listed on the DNP3 website ([www.dnp.org](http://www.dnp.org)) and the full implementation table of the protocol.

The RTU shall have a 10/100 Ethernet port. The Ethernet port shall allow for DNP3.0 communication to the master station, and shall also allow for remote configuration. The RTU shall have the capability of being configured through the web browser. The status of the equipment shall be represented through the web browser. The RTU shall have the ability to import a configuration file for the SCADA point mapping. A template configuration file shall be loaded on each RTU delivered to eThekweni Water and Sanitation. This template shall be developed by eThekweni Water and Sanitation together with the successful bidder. The configuration file shall be exportable and in a readable format and shall be workable when the RTU is disconnected i.e. when offline.

The RTU shall have comprehensive self-test and diagnostic facilities. Alarms from self-test shall be

able to be configured as internal indication bits within the DNP3.0 protocol.

The RTU shall have the ability to force remote points and shall support wireless updates.

A modem mounting plate shall be supplied to accommodate a modem of size 300 mm (width) x 250 mm (height) x 100 mm (depth) within the RTU cabinet.

A pre-cut hole of 20 mm diameter for the antenna cabling shall be supplied and sealed with a weatherproof grommet on the top of the RTU cabinet (for both indoor and outdoor RTU units).

All LV wiring shall be wired to spring-loaded terminals within the MV compartment.

All wiring shall be marked with clip-on labels. The wiring labelling standard for SCADA which shall be used is as follows:

a. Tele-Control Labelling

W – Control  
X – Status Digital IP  
XC – Current Analog  
XE – Voltage Analog

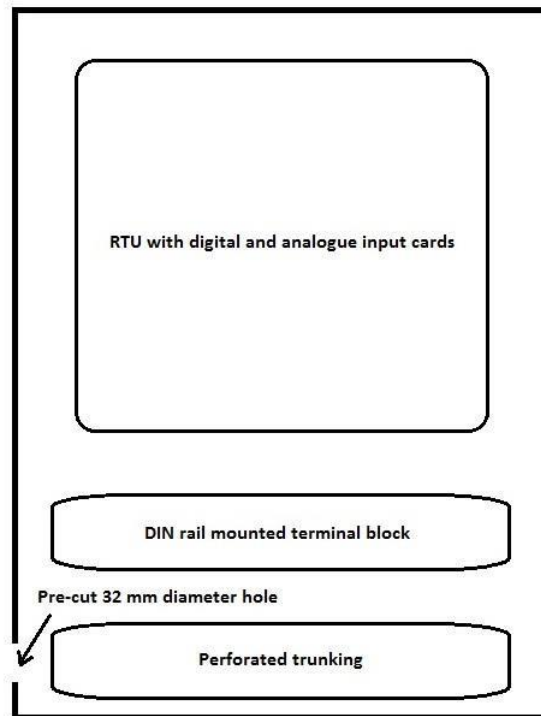
b. Other Field Wiring

A – Main protection Differential  
AL – Alarms (General)  
B – Bus Zone  
C – Backup Protection  
D – Metering  
E – VTs  
J12 – Unfused d.c.  
K – Fused d.c.  
T – Pilots

Full wiring diagrams shall be supplied with the bid documents.

For indoor RTU units, a pre-cut 32 mm diameter hole shall be provide on the bottom left side of the RTU cabinet to align with perforated trunking within the cabinet. This hole shall be sealed with a weatherproof grommet.

Above the perforated trunking, a DIN rail mounted, terminal block shall be provided to cater for 32 points. From these 32 points, 24 digital inputs and 8 analogue inputs shall be prewired to the RTU cards. Refer to the Figure 3 below.



**Figure 3 – RTU cabinet layout for indoor RTU units**

**EA15.2.5**    Markings and Labelling

Each mini-substation and ring main unit shall comply fully with SANS 1029 and SANS 1874 for all markings and labelling.

A brass registration number plate of size at least 15 mm x 60 mm shall be securely fitted to each ring main unit and transformer. The number to be inscribed on the registration number plate shall be given at time of ordering.

**EA15.2.6**    Tests

The mini-substation shall be type tested in accordance with SANS 1029.

The ring main unit shall meet or exceed the requirements of the type tests of SANS 1874.

Type test reports detailing the test procedures and test results on the mini-substations and ring main units offered, shall be submitted with tender documents. The test reports shall be from a recognised test authority. Failure to provide details of tests called for may result in the rejection of the bid.

**EA15.2.7**    Documentation

Full technical and descriptive details, relating to all the items offered in this enquiry, shall be submitted so that the offer can be fully evaluated. This shall include:

- Materials used;
- Method of manufacture;
- Details of quality assurance procedures;
- Drawings; etc.

An electronic copy in an excel format of the rating plate data and information of the mini-substations and ring main units shall be provided with each delivery. EThekwini Water and Sanitation will provide

the template in which the data shall be entered and submitted as required.

Each item shall be delivered together with an inspection checklist for the item. The checklist shall be provided by eThekwini Water and Sanitation to the successful bidder and may be subject to revision.

#### EA15.2.8 Training

Training shall be provided as follows:

- a. Switchgear Operator training priced per session comprising of 10 candidates.
- b. Switchgear Maintenance training priced per session comprising of 10 candidates.
- c. SCADA and RTU training priced per session comprising of 10 candidates.

The venue shall be provided by eThekwini Water and Sanitation .

All hardware and firmware shall be provided by the successful bidder.

All training material shall be provided by the successful bidder.

The content of the training for items A15.2.8 a) and b) shall be in accordance with the manufacturer's requirements.

The content for item A15.2.8 c) shall include installation and commissioning of the RTU as well as all aspects relating to settings and engineering of configurations.

#### EA15.2.9 Delivery Requirements

Delivery of goods shall be to eThekwini Water and Sanitation, Hammarsdale Waste Water Treatment Works

The successful tenderer shall give a 24 hour notice of arrival of each batch of mini-substations and ring main units by road transport to avoid delays in off-loading. Deliveries shall not be accepted on Saturdays, Sundays, public holidays and after hours.

#### EA15.2.10 Health, Safety, and Environmental Issues

Tenderers shall provide, the following information in respect of each product offered:

- A list of all materials used in the product, including packaging, and associated chemical data sheets;
- Whether the product poses any health or safety risks to persons handling the product. In addition, if there are risks, the protective gear required to handle the product, e.g. leather gloves, masks, etc.;
- How the product should be stored and its shelf life;
- How the product should be disposed at the end of its useful life or in the event of failure of the product;
- Whether any toxic by-products are produced (whether in gaseous, solid or liquid form) in the event of the product being exposed fire or heated to elevated temperatures;
- Any other pertinent and relevant information relating to health, safety, and environmental issues; and
- What percentage of the product can be recycled.

## **EA16 BATTERY CHARGING UNITS AND ASSOCIATED VENTED NICKEL CADMIUM BATTERY BANKS**

### **EA16.1 Scope**

This specification details the manufacture, testing, supply and delivery of DC backup battery and charger units as specified below and in Technical Schedule EB5.

### **EA16.2 Bid Information**

Bidders shall give full technical and descriptive details as outlined in Technical Schedule EB5 under Annexures and submit related literature and drawings for the items offered. Failure to supply full information may render the bid liable to disqualification.

### **EA16.3 Normative References**

The following standards contain provisions that through reference in the text, constitute requirements of this specification. At time of publication, editions indicated were valid.

- NRS 026 - Battery chargers - Industrial type for rated ac voltages up to and including 525 V - Preferred requirements for application in their organizations by the dc and standby equipment representative user group.
- SABS 1091 - National colour standards for paint
- SABS IEC 269-2: Low voltage fuses: Part 2 - Supplementary requirements for fuses for use by authorized persons (fuses mainly for industrial applications).

Bidders shall note that, as all standards are subject to revisions, they are encouraged to investigate the possibility of applying the most recent edition of the above standard.

### **EA16.4 System and Operating Conditions**

The wall mounted switchgear tripping battery and charger units are for use in eThekweni Electricity's area of supply and shall be designed to operate satisfactorily when subjected to the following operating conditions:

- Climate humid and sub-tropical
- Altitude from sea-level to 1 000 m
- Ambient temperature from 0°C to 50°C
- Maximum relative humidity 98%

### **EA16.5 Requirements**

#### **EA16.5.1 General**

The wall mounted switchgear tripping battery and charger units, shall comply with the requirements of NRS 026 or other equivalent standard, unless otherwise specified below.

#### **EA16.5.2 AC Supply Details to Charger**

The unit shall be suitable for supply from a 230 V single phase, 50 Hz, local 16 A UPS type switch socket outlet.

Each unit must be provided with 2 m of adequately rated flexible cable, terminated in a 16A, three pin, UPS-type plug, fitted with a red plug top.

#### EA16.5.3 DC Tripping Supply from Batteries

The tripping supply from the whole unit shall be 110 V dc, as specified in Technical Schedule EB5 and be derived from series-connected cells as described under SECTION EA16.5.6.

The positive and negative outputs shall each be isolated by a fuse-link and holder, complying with SABS IEC 269-2 or other equivalent standard. Termination of the voltage shall be on Klippon spring loaded terminals with pre-insulated lugs.

#### EA16.5.4 Duty Requirements

The complete unit shall be capable of meeting the following duty requirements:

- Specific duty requirements for Items 1 and 2
  - AC supply ON
    - a) supply a standing load of up to 0,45 A at 30 V dc or 110 V dc, which may or may not be present; and at the same time
    - b) supply a switchable standing load of 57 mA, which may or may not be present; and at the same time
    - c) supply 6 individual switch tripping coil requirements of 34 A dc for 100 ms each; and at the same time
    - d) maintain cells in a fully charged condition.
  - AC Supply OFF
    - a) supply a standing load of up to 0,45 A at 30 V dc or 110 V dc for 15 hours after loss of the ac supply; and thereafter
    - b) supply 6 individual switch tripping coil requirements of 34 A dc for 100 ms each; and thereafter
    - c) retain sufficient battery capacity to continue charging when the ac supply is re-instated after 15 hours, without loss of battery life.
- Specific duty requirements for Items 3 and 4:
  - AC supply ON
    - a) Supply a standing load of up to 1,5 A at 110 V dc or 1,5 A at 220 V dc, which may or may not be present; at the same time
    - b) Maintain cells in fully-charged condition.
  - AC Supply OFF
    - a) Supply a standing load of up to 1,5 A at 110 V dc or 1,5 A at 220 V dc for 8 hours after loss of the ac supply, and thereafter
    - b) retain sufficient battery capacity to continue charging when ac supply is re-instated after 8 hours, without loss of battery life.

#### EA16.5.5 Enclosure

The battery and charger shall be housed in a vertical metal enclosure, galvanized to inhibit corrosion. Suitable surface preparation shall be applied prior to the application of two coats of light grey enamel paint colour No. G29 of SABS 1091.

The enclosure shall be divided into an upper and lower compartment with the charger housed in the upper compartment and the battery in the lower. The upper compartment shall be fully sealed to prevent ingress of dust and dirt and the products produced during charging of the battery.

The charger unit shall be mounted such that all the components are mounted on/in a removable tray/box for quick and easy replacement (of the whole unit), repair and/or inspection. The main input and outgoing circuits shall be terminated on a terminal block (spring loaded Klippon) inside the top chamber within easy access from two 20 mm holes for the attachment of standard conduit or

pressure glands for alarms and tripping supplies. These holes shall not be cut out by the bidder but rather by the installation team, therefore ensuring hole placement in the required position to suit each installation.

The lower compartment shall contain the battery and shall be ventilated to permit the escape to atmosphere of any gases generated during charging. The battery shall be mounted in such a manner so as to permit adequate clearance space above the upper/back cells so as to allow all aspects of maintenance to be carried out ie, checking the voltage, specific gravity and topping up of water of each individual cell, where applicable, without the removal or disconnection of the whole battery. To enable the enclosure to be transported without the individual cells or the whole battery being displaced, the necessary transport brackets shall be supplied and fitted.

The enclosure shall have a front access door, fitted with swivel type latches which may be sealed closed with a conventional lead seal and wire, such that this door fully seals the upper compartment and closes the lower and prevents unauthorised access. If a standard panel lock is also supplied then a key shall be provided with every enclosure. All specified instruments, switches, LEDs, etc. (of the charger unit) shall be visible with the door closed.

Substantial mounting brackets shall be fitted to the rear of the 30 V charger unit sides (not top or bottom) of the enclosure to permit fixing the unit to the wall. The side mounting brackets shall have inverted keyhole slots cut out so as to facilitate easy mounting by one person. The keyhole dimensions shall be a hole of 12 mm and a slot of 8 mm wide by 12 mm long. The 110 V, 220 V charger unit shall have floor mounting lugs so as to facilitate mounting from the outside of the cubicle. The hole dimensions shall be 12 mm.

Items 2 and 3 shall have identical dimensions (to house the bigger size capacity battery).

#### EA16.5.6 Cells and Battery

Requirements for Items 1 and 2:

- a. The battery shall be of the nickel-cadmium type, which requires low maintenance, it is advisable to have containers including several cells in series in order to optimise the installation cost. Each block shall have a lid that covers connectors and valves to keep them clean. The battery shall have a minimum capacity of 29 ampere hours and housed in a transparent case. The battery shall be capable of satisfying the duty requirements without reducing the service life of the cells to less than 15 years. The cell connections shall be of a nut and bolt type with easily removable nickel-plated copper connecting straps. The nut and bolt shall be stainless steel (grade 308 or equivalent). The number of cells shall be chosen such that the output voltage is at no time greater than 15% above that specified.
- b. Vented cells shall be supplied in a transparent plastic case and the cells shall be step mounted in a tray so that the electrolyte levels of all the cells are easily visible.
- c. The tray shall be galvanised and painted, and be deep enough so as to carry all the cells and the full volume of electrolyte from one cell. The tray shall be totally removable with all the cells interconnected.
- d. Vented cells shall be supplied with transport caps fitted, and plastic fliptop vent caps ready for fitment at the time commissioning the cells.
- e. Each battery bank shall be supplied with the correct Box/Link spanner set.
- f. The cells shall be delivered in a fully charged condition suitable for immediate service. The individual cells shall all have been tested to 100% capacity before delivery.
- g. The battery service life shall preferably be 20 years but not less than 15 years.

Requirements for Items 3 and 4:

- a. The battery shall be of the nickel-cadmium type, which requires ultra low maintenance, it is advisable to have containers including several cells in series in order to optimise the installation cost. Each block shall have a lid that covers connectors and valves to keep them clean.
- b. The possibility of thermal runaway shall be eliminated by intrinsic design of the battery.
- c. The cell containers shall be made of translucent polypropylene and shall be welded together. The electrolyte level should be visible through the side walls and "min" and "max" electrolyte level marks shall be displayed.
- d. The battery shall withstand prolonged float operations without any loss of capacity.
- e. The battery design life shall be in excess of 20 years at 20°C in standby float application.
- f. Bidders shall give a clear statement of this and support their offers with manufacturers specifications to this effect.
- g. The battery shall have a minimum capacity of 17 ampere-hour.

#### EA16.5.7 Charger Unit

Requirements for Items 1 and 2:

- a. The charger unit shall be kept as simple as possible with LEDs and indicators mounted on the front panel of the charger unit.
- b. The charge unit shall be capable of meeting the following two separate requirements:
  - i. supply the continuous switchable standing load; and
  - ii. maintain the battery at full charge whilst the ac supply remains ON irrespective of whether the standing load is present or not.
- c. The standing load may be switched off and the charger design shall allow for this.
- d. The boost voltage shall not exceed that specified by the cell manufacturer.
- e. The float voltage shall be set to that specified by the cell manufacturer.
- f. The "ON/OFF" switch, "BATTERY TEST" push-button and "BOOST/FLOAT" manual push-button shall be situated externally on the charger unit but not on the front face (ie. inside the enclosure when the door is closed).
- g. The "Alarm Accept/Reset" switch shall be fitted on the front face of the charger unit.
- h. The manual boost shall not be a switch but a push-button. When the pushbutton is operated, the manual boost shall latch into the "ON" condition for a limited time and then switch "OFF" automatically (ie. trigger an electronic timer circuit). The bidder shall declare this time period which could be used to ascertain the alternative "ON" period for the manual "OFF" pushbutton. Alternatively, the boost condition may be terminated by a manual "OFF" push-button.
- i. The minimum charge shall be 30 V (a 3 ampere unit will be considered) or 110 V dc, 5 ampere unit.

Requirements for Items 3 and 4:

- a. The unit shall be kept as simple as possible with LED's and indicators mounted on the front panel of the charger unit. All equipment and components shall be adequately rated with sufficient tolerance to permit continuous operation without overheating or damage or reduction in life of equipment. Underrated components shall not be accepted, IC's shall be of the plug-in type. All equipment shall be designed to withstand lightning strikes and for surges. All LED's shall be of the Hi-Brite intensity.
- b. The charging unit shall be of the constant voltage, controlled current type suitable for pre-selection of the dc float voltage which is to be maintained across the battery to within + 1% for a variation in ac supply voltage of + 10%. The voltage adjusting devices shall be mounted inside the panel and provided with screw-driver slots for adjustments. Each adjustment shall be labelled to indicate its purpose and direction to be related either to raise or lower settings.
- c. A double pole ac switch and fuse or circuit breakers shall be provided for the incoming ac supply. The outgoing circuits shall be protected by fuses or MCCB's.



- d. Chargers shall be provided with surge suppressers for protection against di-ode failure, due to voltage transients.
- e. The charger shall be provided with static overload protection to ensure that in the event of the charger output being short-circuited, the maximum output current is kept to a value within the continuous rating of the charger components.
- f. All indicating instalments shall be of flush-mounting, square dial type. An ammeter shall be provided to indicate charger output.
- g. The unit is to be supplied with 4 outgoing output load circuits, each to be isolated by a fuse and a link or MCB's
- h. The recommended charge shall be 110 V or 220 V dc, 5 ampere unit.

#### EA16.5.8 Wiring and Terminations

The wiring of the various components shall be of not less than 1,5 mm<sup>2</sup> conductor size and shall be terminated in suitably sized anvil-type (Klippon, G-rail type) terminal blocks with pre-insulated lugs. The input and output terminal blocks shall be capable of accepting 2,5 mm<sup>2</sup> conductor. All terminal blocks shall be mounted in such a manner so as to permit easy connection/disconnection from the access doors/covers.

The connections to the charger unit shall be of a plug-in type for quick and easy replacement of a faulty charger unit. This plug shall be polarity conscious and no live pins shall protrude from such a plug. The plugs shall be rated to carry the required current and voltage without deterioration of the plug.

The connections between the battery bank and the rest of the system shall be of a quick release type and be of sufficient rating so as to carry the total rated trip current for the specified length of time. This shall allow quick replacement of the whole battery bank on a draw out tray. This plug shall also be polarity conscious.

#### EA16.5.9 Instrumentation

The following instruments shall be included:

- An ammeter of good industrial grade with a scale length of not less than 95 mm to indicate the charging current.
- A voltmeter (state of charge indicator) matching the instrument in clause 5.9.1, which shall indicate the battery condition when loaded by a resistor switched by a timed push-button mounted inside the top compartment. The indicator shall be clearly marked to indicate whether the battery is fully charged or not when loaded at 1 ampere per ampere hour capacity for approximately 5 seconds.
- An "ON/OFF" switch mounted on the charger unit such that it is not on the front face and the toggle movement is downwards to switch "on".
- An indicating lamp/LED coloured red and mounted on the front panel, to indicate when the charger supply is "on" and labelled "MAINS ON".

#### EA16.5.10 Auto Battery Test

The charger shall have an automatic battery test facility. This facility shall load the bank for a set period of time via a resistor and at set time intervals.

#### EA16.5.11 Auxiliaries/Alarms

- 5.11.1 An ac Supply Fail alarm with a delay of 30 s shall illuminate a red LED and at the same time drop off a dedicated relay which closes a pair of voltage free contacts wired to terminal blocks. This LED shall be clearly labelled "AC SUPPLY FAIL" including the contacts on the terminal block.

- 5.11.2 A Low dc Voltage alarm shall illuminate a red LED and at the same time drop off a relay which closes a pair of voltage free contacts wired to terminal blocks. This LED shall be clearly labelled "LOW DC VOLTAGE" including the contacts on the terminal block.
- 5.11.3 A Battery Test Fail alarm shall illuminate a red LED and at the same time operate a relay which closes a pair of voltage free contacts wired to terminal blocks. This LED shall be clearly labelled "BATTERY TEST FAIL" including the contacts on the terminal block.
- 5.11.4 A two way switching circuit shall be incorporated into the alarm for "AC SUPPLY FAIL" so that in the event of a planned "AC SUPPLY FAIL" the alarm may be accepted. When the supply is restored the alarm will again come up but now can be placed in the run/normal mode. The two way switch shall be labelled "NORMAL" in the one position and "ALARM ACCEPTED" in the other with an overall label "ALARM SWITCH". This shall be visible on the front face of the charger unit. Further to this, all other alarms shall pass through to eThekweni Electricity's Control Centre even while the AC Supply Fail alarm is in the "ALARM ACCEPTED" mode (for Item 1 and 2 only).
- A suitable earth-fault detection system should be supplied, for earth faults above 10 mA. Provision should be made for local and remote indications of positive and negative earthfaults for the 110 V systems only and 220 V systems only.

#### EA16.5.12 Equipment and Component Ratings

All equipment and components making up the complete unit shall be adequately rated with sufficient tolerance to permit continuous operation without overheating or damage or reduction of the stated service life of the equipment. The tripping unit forms an important part of the unmanned substation and underrated components shall not be accepted. ICs shall be of the plug-in type. **All equipment shall be chosen and designed to withstand lightning strikes and/or surges.** All LEDs shall be of the Hi-Brite intensity.

#### EA16.5.13 Spares and Equipment

The successful bid shall supply, if required:

- a. complete charger units;
- b. complete assorted spare kits; and
- c. spare battery packs complete with in line clip/coupling compatible with this specification. Bids shall quote separately for the above spares, as the spares are required for maintenance purposes only.

### EA16.6 Documentation

The following information shall be included with bid documents:

- a. Current/time discharge curves for the battery offered.
- b. Battery voltage/time charge and discharge curves.
- c. The sensing method of charge control and detection of a full charge condition.
- d. Method used to prevent overcharging.
- e. Indication method to indicate full charge.
- f. Tolerances allowed in component rating.

The following shall be supplied by the successful bidder with the first delivery:

- a. Full wiring schematic drawings.
- b. Component layout drawings and circuit diagrams.
- c. Component list including, name, type of component, source and quantity.
- d. Operating manual.

- e. Maintenance Manual.

Bidders attach supporting documents with respect to:

- a. the service life of the batteries and
- b. the equipment design to withstand lightning strikes and/or surges.

Where possible the above information should be supplied on a CD (Compact Disc) and in Autocad format.

#### **EA16.7 Inspection and Testing**

Upon receipt each unit will be fully tested and inspected and any units with visible or electric defects will be rejected. These units shall be removed and replaced or repaired by the contractor as soon as possible after being notified. All units shall be fully tested to ensure compliance with the specification and will be accepted only if they meet the requirements of the specification.

It is recommended that if the units are of a type not previously supplied to eThekweni Electricity, a prototype should be submitted for approval prior to manufacture. Liaison with Mr. Lenny Govender, telephone: (031) 311 9639, responsible for the tripping units is strongly recommended.

Each cell/bank shall be supplied with results of type tests carried out in accordance with NRS 026 on the cell by the cell manufacturer.

Each charger shall be supplied with results of type tests carried out in accordance with NRS 026 on the charger by the manufacturer.

#### **EA16.8 Delivery**

The required wall mounted switchgear tripping battery and charger units shall be delivered by road, direct to the construction site for the eThekweni Waste Water Treatment Works, Durban, South Africa.

Bidders are requested to offer definite delivery periods which are realistic and attainable.

Delays in delivery in this contract could result in discounting further offers from bidders for future contracts for this equipment.

Units shall be clearly marked "FRAGILE" and "THIS SIDE UP" for transporting and storage

The units shall be packaged in a light-open slatted wooden crate/frame.

A packed unit shall be clearly marked the following:

- a. Stock code number
- b. Charger unit capacity; and
- c. Battery capacity

#### **EA16.9 Training**

Provision shall be made to train two staff members from eThekweni Waste Water Treatment Works on the construction site.

Training shall include fault finding down to component level utilising the drawings.

#### **EA16.10 Health, Safety, and Environmental Issues**

Bidders shall provide, the following information in respect of each product offered:

- A list of all materials used in the product, including packaging, and associated chemical data sheets;
- Whether the product poses any health or safety risks to persons handling the product. In addition, if there are risks, the protective gear required to handle the product, eg leather gloves, masks, etc.;
- How the product should be disposed at the end of its useful life or in the event of failure of the product.
- Whether any toxic by-products are produced (whether in gaseous, solid or liquid form) in the event of the product being exposed fire or heated to elevated temperatures;
- Any other pertinent and relevant information relating to health, safety, and environmental issues; and
- What percentage of the product can be recycled.

The bidder shall complete the Acceptance of undertaking in terms of the Occupational Health and Safety Act (Act 85 of 1993).

The successful bidder's installation team shall undergo Ehekweni Water and Sanitation 's Safety Rules course and a subsequent test, after which these persons would be deemed Specifically Trained Persons and issued with a contractor's identity card.

## **EA17 TESTING**

### **EA17.1 Installation Tests**

- a. Tests as stipulated in the "Occupational Health and Safety Act no. 85 of 1993, as amended, and in the "Code of Practice for the Wiring of Premises" SANS 10142 (as amended), must be done. Test report forms must be filled in fully and correctly in ink, signed by the installation electrician and handed to the Engineer or its representative.
- b. Tests must be conducted on site after the whole installation is complete unless the Engineer grants written permission to the contrary. The tests must include a full-load test for an adequate period to ensure the satisfactory working of the installation. If negative test results are obtained, faults must be rectified, and tests again done.
- c. The contractor must supply all testing apparatus, correctly calibrated.
- d. All tests shall be carried out in conjunction with and to the satisfaction of the Supply Authority and in the presence of the Engineer or his representative. The contractor shall make all arrangements for testing and inspection, the costs thereof being included in the Tender Price.
- e. Each length of cable shall be tested for insulation and polarity by means of a 1000 Volt Megger designed for that purpose. In the case of underground cables this shall be done before back filling. In addition, the earth-loop impedance of each conductor earth electrode shall be measured. The earth resistance shall be tested by means of an approved instrument.
- f. "Danger" notices shall be displayed at remote ends of cables under test.
- g. The contractor shall ensure that the installation is completed in every respect and that there are no major defects prior to notifying the Engineer (in writing) for a first delivery inspection. The Engineer will accept zero minor defects during the final inspection. Should the number of defects be exceeded at the final inspection then the Engineer will terminate that inspection and request that the contractor arrange an additional final inspection.

### **EA17.2 Submittals**

Submittals shall include, but not be limited to, the following:

- a. Three (3) copies of certified test results for each test indicated herein, for approval and future references.
- b. Certifications as required herein.
- c. Additional information as required in the specifications.

**EA17.3 Conductor Tests (600 Volts Or Less)**

- a. Prior to energizing of all new feeders, test all conductors for continuity of circuitry and for short circuits. No submittal is required for this test. Each wiring system with devices connected must test free from short circuits and grounds.
- b. Each new feeder conductor shall have its insulation resistance tested after its installation is completed except for connection at its source and point of termination.
- c. Test shall be made using a Megger or equivalent at a voltage of not less than 1000 VDC, and after one minute of operation at slip speed. Resistance shall be measured by connecting one terminal of the megger to the conductor and other terminal to earth. Reading shall be observed after 15 seconds of operation of the megger.
- d. Conductors which do not meet or exceed the following insulation resistance values shall be removed, replaced, and retested.
- e. Conductor test results shall indicate weather conditions, temperature, relative humidity, date and time, feeder tested, conductor size and type and resistance measurements.

**EA17.4 Service Switchboard Earth Resistance Test**

- a. Perform a earth resistance test on the switchboard earthing system for comparison of future inspection and testing data by the Owner. Overall system resistance shall not exceed 25 ohms. Eliminate any stray currents, shorts, or non-consistencies in the grounds system.
- b. The test shall be performed using a Megger Earth Tester or equivalent test instrument and shall not be performed immediately following wet weather conditions.
- c. Switchboard earth resistance test results shall indicate weather conditions for test, earthing system tested, earthing configuration and test results.

**EA17.5 Earth Fault Protection System Tests****A. Factory test**

- a. The switchboard ground fault protection system shall be factory tested prior to shipment.
- b. The switchboard manufacturer shall provide factory ground fault interlocking and protection system test for circuit testing, and verification of interlocking and tripping characteristics. The manufacturer shall pass predetermined values of current through the relay sensors, and measure the relay tripping time for each phase, and neutral. The measured time/current relationships shall be compared to the relay trip characteristics curves. If the relay trips outside the range of values indicated on the curve, the relay shall be replaced. This test shall include verification of polarity of the ground sensor circuits' interconnection.
- c. Certified "factory test" results shall indicate relay number, device served, actual characteristic curves, design characteristic curves and overall test results.

**B. Field test**

- a. Following completion of the construction and prior to final acceptance testing, the earth fault protection system shall be field tested and reset to the manufacturer's recommended setting for both time and current, by a representative of the Manufacturer. The field test shall be conducted in a similar manner to the factory test in that a cable from a low voltage, high-current test set shall be passed through each current sensor. This test shall also demonstrate the complete system reliability in that it must operate the associated shunt trips and show that the overcurrent devices which they operate will actually open.
- b. Certified "field test" results shall indicate relay tested, relay settings, and test results.

**EA17.6 Generator System Tests**

- a. Upon completion of installation of the electric generating system and after the building normal power source has been energized, test the package electric generating system to demonstrate standby capability and compliance with specified requirements, including automatic start-up, controls, full load acceptance, and automatic shut-down.
- b. Tests shall include operation of the standby electric power system with voltage check while the system is operating to ensure proper operation of the generator, transfer switches, and other system components.
- c. Operation of the system shall simulate standby power conditions, that is, a simulated loss of main electrical power to the building with sufficient load available in the building systems or through the use of a portable load bank to sufficiently demonstrate packaged electric generating system. Test period shall be minimum of 2 hours continuous trouble-free operation with at least 4 automatic transfer switch operations (each switch) within the period of operation.
- d. Refer to the relevant specification for additional generator systems tests.

**EA17.7 Special Testing**

Certify in writing that the system operation is in accordance with specifications and code requirements.

**EA17.8 Balancing Of Electrical Circuits**

- a. The system of feeder and branch circuits for power and lighting shall be connected to distribution board busbars in such a manner that loads connected thereto will be balanced on all phases as close as practicable.
- b. Should there be any unfavourable condition of unbalance on any part of the electrical system, the electrical contractor shall make such changes that may be necessary to remedy the unbalanced condition.
- c. Prior to completion of the project, provide a complete list of all panels stating the measured loads on each phase. Test results shall indicate panels tested, amperage per phase, and any remedial action taken.

**EA17.9 Operational Testing**

- a. Take voltage and currents readings for each feeder and motor circuit under maximum operating conditions. Questionable readings shall be repeated at no cost for confirmation.
- b. Controls for lighting and receptacle circuits shall be demonstrated.
- c. Demonstrate running of motors with controls and interlocks.
- d. Demonstrate operation of electrical equipment appliances.

**EA17.10 Cables**

- a. Each cable shall be tested after installation in accordance with SANS 1507 (up to 1kV) and SANS 97 (up to 11kV) as well as the requirements of the local and supply authorities.
- b. LV cables shall be tested by means of a suitable megger at 1kV and the insulation resistance shall be tabulated and certified.
- c. MV cables shall be pressure tested in accordance with the manufacturer's recommendations and exact leakage current shall be tabulated and certified.
- d. 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.
- e. The contractor shall notify the Engineer and if applicable the Supply Authority timeously so that their representative may witness the tests.

- f. On completion of the tests on any cable, the contractor shall without delay submit three (3) copies of the certified test results to the Engineer.
- g. The contractor shall provide all the testing equipment as required for the respective tests.

#### **EA17.11 Density of Bedding and Back Fill Material**

- a. The Engineer may demand a density test to determine the grade of density at the bottom layer of the trench and of the approved back fill material.
- b. If the density is lower than specified the Engineer may demand the removal of the material, replacing of the bottom layer or the back fill material with the same or other material, and the re-compaction, on the contractor's own expense.

#### **EA17.12 Electrical Tests**

- a. Every part of the cable network between CDU's and substations must be tested for electrical continuity and for insulation resistance. Acceptance tests must consist of the following.
  - Phase identification test
- b. A test must be done to determine if the connections between the end points are correct. All cables must be phased out before connected to the switchgear.
  - Insulation resistance test (Low voltage cables)
- c. The resistance of the insulation of every core to earth and to every other core must be determined. These tests must be done with a 2 000 V insulation resistance tester on paper and PVC insulated cables.