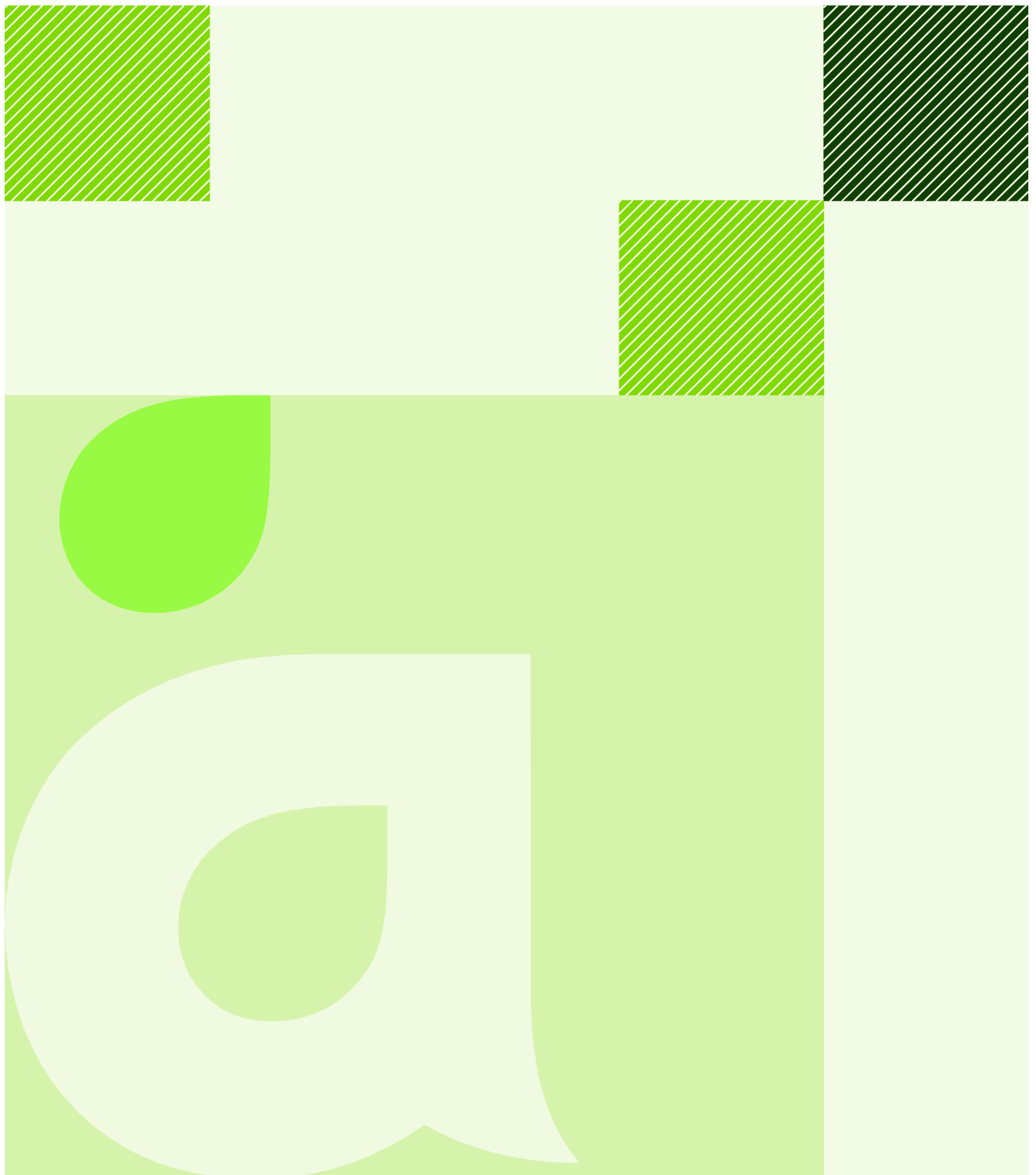




Engineering Standard
Cable Support Systems

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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.
- 1.1.2 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.
- 1.1.3 Note, however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, thorough reference must be made to the relevant statutory documentation.

1.2 Electrical System Characteristics

- 1.2.1 The design of the installation shall comply with SANS 10142-1.
- 1.2.2 The design of the installation shall consider the following supply characteristics:
 - a) Voltage, frequency and number of phases
 - b) Maximum prospective short circuit current (phase to phase and phase to neutral)
 - c) Type of system, e.g. TN-S, TN-C-S
 - d) Maximum earth loop impedance of the earth fault path external to the installation
 - e) Type and rating of the cut-out or switch device
 - f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment
- 1.2.3 The installation of protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.
- 1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and adequate working space for such activities. Similarly, the positioning of equipment shall not impede access to, or working space at, non-electrical equipment and services for operation and maintenance activities.
- 1.2.5 The installation shall be suitable for access and use by electrically unskilled persons.
- 1.2.6 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.
- 2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.
- 2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:
- a) Occupational Health and Safety Act (Act 85 of 1993)
 - b) Construction Regulations 2003 issued in terms of Section 43 of the Act
 - c) Local Fire Regulations; and
 - d) Regulations of the Local Supply Authority
- and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1063	Earth rods, couplers and connections
SANS 1085	Wall outlet boxes for the enclosure of electrical accessories
SANS 1088	Luminaire entries and spigots
SANS 1091	National colour standards of Paint
SANS 1195	Busbars
SANS 1213	Mechanical cable glands
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1266	Ballasts for discharge lamps (excluding tubular fluorescent lamps)
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1431	Weldable structural steels

Standard Number	Description
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1700	Fasteners
SANS 1777	Photoelectric control units for lighting
SANS 1783	Sawn softwood timber
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 10155	Accuracy in buildings
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10177	Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400	The application of the National Building Regulations
SANS 60269	Low-voltage fuses
SANS 60309	Plugs, socket-outlets and couplers for industrial purposes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
SANS 60669	Switches for household and similar fixed-electrical installations
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
SANS 61048	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(Um = 36 kV)
SANS 61643	Low-voltage surge protective devices
Other Standards	Description
ARP 035	Guidelines for the installation and maintenance of street lighting
BS 88	Specification of supplementary requirements for fuses of compact dimensions for use in 240 / 415 V industrial and commercial electric installations
IEC 157	Low voltage switchgear and control gear
IEC 408	Low voltage air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units
IEC 12373	Aluminium and aluminium alloys. Anodizing. Method for specifying decorative and protective anodic oxidation coatings on aluminium
IEC 50086	Conduit systems for cable management
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations

2.2.2 Standards are often tailored to the conditions of their country or origin (in terms of permissible voltages, expected ambient temperatures, etc.). Therefore, and unless normatively referenced to the contrary in a Standard of higher precedence, the decreasing order of precedence of Standards shall be:

- a) South African National Standards (SANS, VC, etc.)

- 
- b) South African Sectoral Standards and Specifications (NERSA, CKS, ARP, NRS, PIESA, etc.)
 - c) ISO Standards
 - d) IEC Standards
 - e) Harmonized British Standards (BS EN)
 - f) Other Harmonized European National (EN) Standards (CEN, CENELEC, ETSI)
 - g) Non-Harmonized British Standards (BS)
 - h) Other international standards

2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

- a) This Specification, including all Technical Data Sheets; and
- b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. INSTALLATION OF CABLE SUPPORTS

3.1 Cable Trays, Mesh and Ladders

3.1.1 General

- a) Cable management systems (cable trays, cable ladders and cable mesh) shall be selected and installed strictly in accordance with their manufacturer's guidelines, with a safety factor of 1.5 after taking into account maximum permissible loading and all external factors (not limited to wind, snow and thermal expansion). Upon demand to do so, the Contractor must furnish all data and calculations he used to derive the type and spans of the systems to the Engineer.
- b) Notwithstanding above, the deflection of a cable management system due to installed cable weights shall be, in accordance with IEC 61537, limited to 1/100th of the span.
- c) Except where it is to be installed in locations with corrosive atmospheres, cable management systems shall be manufactured of galvanized and/or epoxy-powder coated steel. In locations with corrosive atmospheres, systems shall be manufactured from stainless steel (316 Marine Grade) or aluminium.
- d) All clamps, clips, hinges screws, bolts, nuts and support fittings used for fastening cable trays or cables shall be of the same material as the cable management system itself.
- e) Over and above the requirements of SANS 10142-1, all cable tray and ladder systems that will support telecommunication and / or control wiring shall be bonded in accordance with NRS 083-2 (gives details of bonding methods that provide enhanced protection against the effects of electromagnetic cross-interference).
- f) Cable management systems shall be selected and installed such that spare capacity (weight as well as height and width) of 20 % will be available for the addition of future services (the cable management system to still exhibit a 1.5 safety factor after services were added).

3.1.2 Cable Trays

- a) All cable trays shall be of the heavy duty, increased upstand ("siderail"), type.
- b) Metal cable trays shall be manufactured from base-perforated (in excess of 30 % of the surface area, in accordance with SANS 10142-1, in other words, class D according to Table 4 of IEC 61537) rolled steel. Metal trays manufactured to the following standards shall be used:
 - i) Less than 150 mm wide: 1,2 mm minimum thickness with 12 mm minimum upstand
 - ii) 150 mm to 450 mm: 1,2 mm minimum thickness with 19 mm minimum upstand
 - iii) Above 450 mm (heavy duty): 2,5 mm minimum thickness with 76 mm upstand
- c) The edges of cable trays are to be turned up on both sides to improve rigidity (return flange cable tray), and, where necessary, the sides of trays shall be reinforced with galvanised steel angles, minimum 25 x 25 x 3 mm, with 25 x 3 mm cross-braces at 600 mm centres.
- d) Cable trays shall be hot-dip galvanised only after the perforation and bending processes have been completed.

3.1.3 Cable Ladders

- a) Metal cable ladders shall have side rails with 2 mm minimum thickness. Cross rungs shall be spaced at maximum intervals of 300 mm (measured between the centres of rungs). Where cables of 10 mm² or smaller are installed on cable ladders, the spacing of cross rungs shall be reduced to 125 mm.
- b) Cable ladders consisting of slotted metal rails which accommodate plastic or metal cable binding bands may be used in vertical cable runs against walls, etc. These cable

ladders will be considered in horizontal cable runs for small cables for communication and control wiring only after approval by the Engineer.

3.1.4 Cable Tray and Ladder Connections

- a) Cable tray and ladder connections shall be suited to and of the same manufacture as the linear sections that they connect.
- b) The dimensions of these connections shall correspond to the dimensions of the linear sections to which they are connected.
- c) The radius of all bends shall be 1 m minimum. The inside dimensions of horizontal angles or connections shall be large enough to ensure that the allowable bending radii of cables are not exceeded.
- d) Sharp angles shall be 45° mitred.

3.1.5 Installation of Cable Trays, Cable Ladders and Cable Mesh

- a) The spacing between tiers of ladders, trays and/or mesh shall be 300 mm minimum. Furthermore, they shall be installed such that a minimum separation of 300 mm exists between ceilings and the top of a tray or ladder (where the latter is installed horizontally) and 50 mm between the nearest sides of trays or ladders and the finished surfaces of walls, floors and ceilings for other configurations.
- b) Fixing materials shall be compatible with cable management system materials, and offer resistance to corrosion.
- c) Cuts in trays shall not pass through perforations, except where practically impossible to implement.
- d) Cable trays and mesh shall be mounted with a minimum air gap of 25 mm between the underside of the tray and the mounting surface.

3.1.6 Installation of Cables on Cable Trays, Ladders and Mesh

- a) Cables shall be supported to avoid damage during installation, prior to dressing and fixing.
- b) Depending on the overall diameter, single cables and groups shall be secured according to the following.

Table 2: Installation of cables

	Overall Diameter
Nylon UV Protected Cable Ties	< 35 mm
Propriety cable clamps	> 35 mm

- c) In outdoor applications, where the installation maybe subject to ultra-violet light, PVC covered aluminium tape shall be used instead of nylon cable ties.
- d) Cables installed in groups shall be installed in straight lines and not cross over each other, except where single core cables need to be transposed.
- e) Where cables exit ladders, trays or mesh, the latter shall be formed or covered with PVC to ensure a smooth surface.
- f) Where single core cables are installed in trefoil formation, trefoil cable clamps shall be used.

4. DRAWINGS AND DOCUMENTATION

4.1 General

4.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

- a) The Client's name and contact details
- b) Client's project / scheme / contract reference title and numbers
- c) The Engineer's name and contact details
- d) Engineers reference numbers
- e) Contractor's works / contract / order references.

4.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

4.2 Drawings for Approval

4.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

- a) Cable route layout drawings showing
- b) Type of wireways
- c) Trenching
- d) Cable junction boxes

4.3 As-built Drawings

4.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

- a) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and
- b) Cable routes (including any cable joints)
- c) General arrangement drawings
- d) Single Line Diagrams

4.4 Operating and Maintenance Manual

4.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

4.4.2 The operating and maintenance manuals shall include at least the following:

- a) A schedule of installed components and equipment, containing the following information:
 - i) Manufacturers name and contact details
 - ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and
 - iii) Function (e.g. switching lighting circuit DB03-L1)
- b) A schedule of all installed cables, with the following information:
 - i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)
 - ii) Size

- 
- iii) Installed length; and
 - iv) Function (e.g. "Feeding Submersible pump IW-SP-01")
 - c) Description and details w.r.t:
 - i) Detailed description of the function of all operator controls
 - ii) Procedures for fault finding
 - iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures
 - iv) Inspection schedules; and
 - v) Spare part information and recommended spares

5. TESTING AND COMMISSIONING

5.1 General

- 5.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.
- 5.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.
- 5.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.
- 5.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.
- 5.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.
- 5.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.
- 5.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.
- 5.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.
- 5.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

5.2 Test Sequence

5.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

- a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards
- b) All parts of the installation are correctly selected and erected
- c) No part of the installation is visibly damaged or otherwise defective
- d) The installation is suitable for the environmental conditions; and
- e) The installation complies with this Specification

5.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 5.2.1, the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

- a) Continuity of conductors
- b) Resistance of Earthing conductor

- 
- c) Continuity of ring circuits Earth fault loop impedance at main switch
 - d) Elevated voltage on supply neutral Earth Resistance
 - e) Insulation resistance
 - f) Voltage, main distribution board - no load
 - g) Voltage, main distribution board - on load
 - h) Voltage at available load
 - i) Operation of earth leakage units
 - j) Earth leakage test button
 - k) Polarity at points of consumption
 - l) Switching devices



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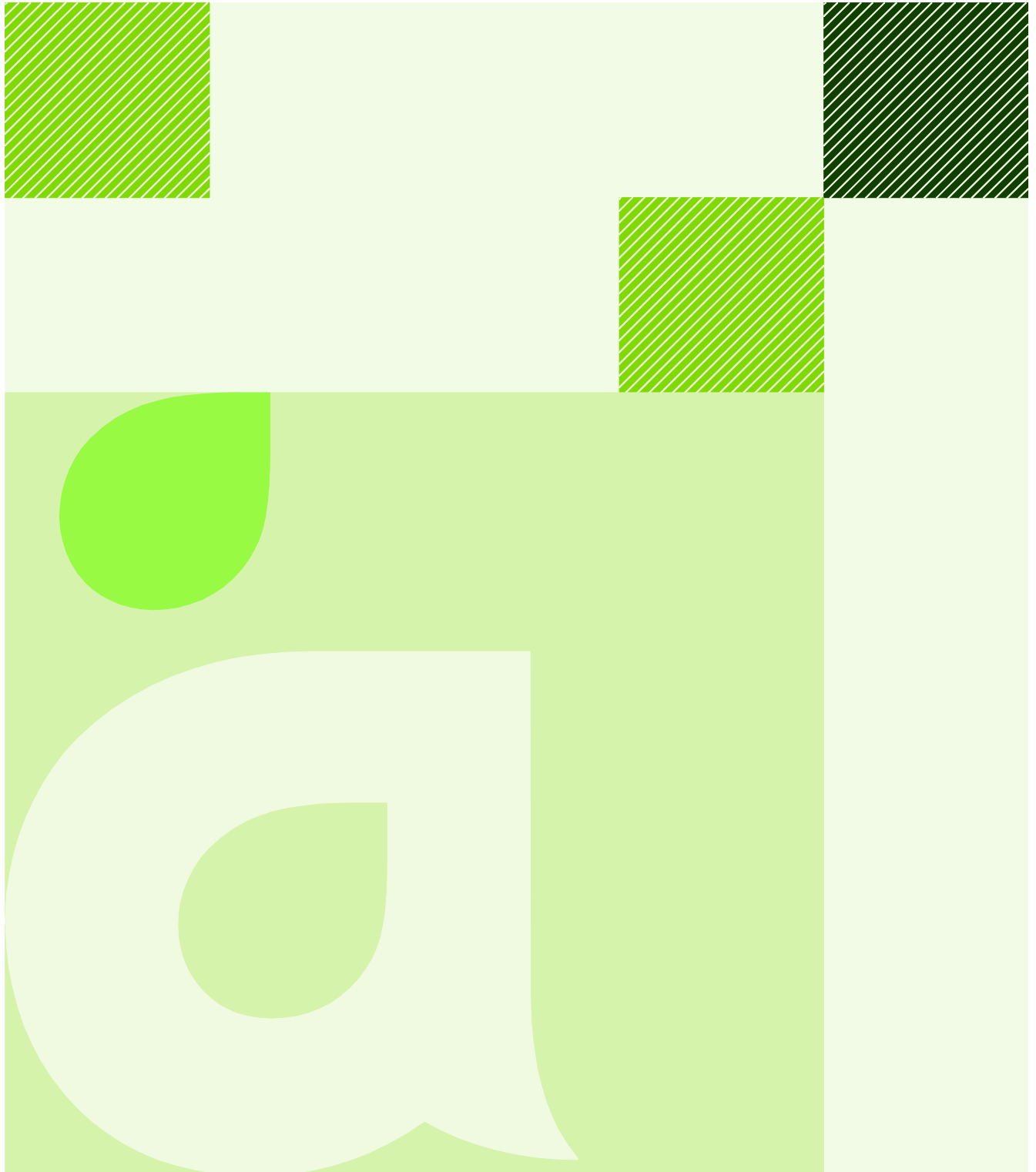
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Electrical Valve Actuators

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Tables

Table 1: Reference Standards

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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the performance, design, construction, installation, testing and commissioning of electric actuators used to automate valves, penstocks, weirs, etc.
- 1.1.2 The primary intention of this Specification is to ensure the provision of an electrical installation which has been properly designed and constructed to ensure safe reliable operation and to facilitate safe inspection, test and maintenance.

1.2 General

- 1.2.1 The completed installation shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Particular Specification / Technical Data Sheets / this Specification under all foreseeable conditions; whether or not they have been explicitly detailed, to provide the end user of the installation or the end user's nominated representative (hereafter referred to as the Employer) with a fully working installation.
- 1.2.2 All materials, components, and equipment used for the installation of electric valve actuators shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.
- 1.2.3 Equipment with replaceable spare parts shall be available for a purchase period of five (5) years from the date of acceptance of the system.
- 1.2.4 For complete definition of requirements, this Specification must be read in conjunction with the Scope of Works, the Particular Specification and Technical Data Sheets associated with the respective material requisition documentation.

1.3 Installation Performance Requirements

- 1.3.1 The installation shall be suitable for its intended duty with respect to the electrical supply, distribution, and load requirements.
- 1.3.2 The installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.
- 1.3.3 The installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components parts.
- 1.3.4 The installation shall be compatible with new or existing equipment, pumps, penstocks, sluice gates, valves and data communications network.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detail specification of the project or site specific requirements will be found in the Particular Specification / Specification Data and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.
- 2.1.2 The design, construction, installation, inspection, testing and commissioning of the Installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.
- 2.1.3 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.
- 2.1.4 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the Installation shall comply with all relevant Statutory Regulations and Directives including:
- a) Occupational Health and Safety Act (Act 85 of 1993)
 - b) Regulations of the Local Supply Authority
- 2.2.2 All electric valve actuators shall be provided in accordance with current best practice and all applicable statutory and recognised requirements and standards, and shall be constructed and assembled with a high level of skill and craftsmanship.
- 2.2.3 The entire works shall be carried out in accordance with the requirements of all the relevant Government Acts and Regulations

2.3 Recognised Standards

- 2.3.1 The latest edition, including all amendments up to date of tender of the following particular national and international specification, publications and codes of practice shall be read in conjunction with this specification and shall be deemed to form part thereof:

Table 1: Reference Standards

Standard Number	Description
SANS 664	Cast iron gate valves for water works
SANS 1123	Steel pipe flanges
SANS 1804	Induction motors
SANS 10083	The measurement and assessment of occupational noise for hearing conservation purposes
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142	Standard Regulations for Wiring of Premises
SANS 60034	Rotating Electrical Machines
SANS 60204	Safety of machinery. Electrical equipment of machines.
SANS 60529	Degrees of protection provided by enclosures (IP Code)

Standard Number	Description
SANS 60730-2-14	Automatic electrical controls for household and similar use: Particular requirements for electric actuators
SANS 60947-7	Specification for low-voltage switchgear and controlgear. Ancillary equipment.
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory
Other Standards	Description
BS 4999	General requirements for rotating electrical machines
BS EN ISO 5210	Industrial valves. Multi-turn valve actuator attachments
BS EN ISO 5211	Industrial valves. Part-turn valve actuator attachments.
BS EN 12570	Industrial valves. Method for sizing the operating element
BS EN 60085	Electrical insulation. Thermal evaluation and designation

3. GENERAL REQUIREMENTS

3.1 General

- 3.1.1 The actuator shall typically incorporate an electric motor, integral reduction gearing, reversing motor starter, local controls, torque and position limit devices and contacts for remote control and monitoring, all housed in a sealed enclosure.
- 3.1.2 The actuator shall provide the means for local and remote valve operation and shall also provide a means of manual valve operation (handwheel) during electric power interruption. The local/remote-control selection switch shall be designed with a locking device to inhibit unauthorized adjustments being made to the valve settings.
- 3.1.3 The Contractor shall provide the first fill of lubricants to all components/systems requiring lubrication.
- 3.1.4 Actuators shall be capable of being mounted and operated in any vertical/horizontal inclination.
- 3.1.5 The actuator shall be delivered with suitable protection against damage and ingress of moisture, whilst in temporary storage, without an electricity supply.

3.2 Preference of Manufacturer

- 3.2.1 All Actuators shall be standard catalogue models and shall be readily available.
- 3.2.2 All actuators shall, where possible, be from the same manufacturer and shall have the same interchangeable frames. Variations in type and size shall, where possible, be limited to prevent stocking a variety of special spares.
- 3.2.3 Equipment which has not previously been in common use in South Africa shall not be acceptable unless specifically called for in the Particular Specification or unless the Engineer agrees in writing.

3.3 Electrical Supply Characteristics

- 3.3.1 Unless otherwise specified on the Technical Data Sheets, the actuator shall be suitable for a 380/400/415 V, three phase, three wire, earthed neutral, 50 Hz supply.
- 3.3.2 The actuators shall be capable of operating within $\pm 10\%$ of the nominal supply voltage without risk of damage. All actuators shall be suitable for operating continuously under actual service conditions, including the $\pm 10\%$ voltage tolerance.
- 3.3.3 The actuator shall be capable of operating under conditions of three (3) phase supply imbalance, where the negative and zero phase sequence components of the voltage do not individually exceed 2 % of the positive phase sequence components.
- 3.3.4 All actuators shall be capable of operating continuously under actual service conditions at any supply frequency between 48 and 51 Hz.
- 3.3.5 The actuator shall be designed to remain in position without damage upon failure of the electrical supply.

3.4 Weight

- 3.4.1 The weight of the actuator and the heaviest individual maintenance and erection lifts shall be as stated on the Technical Data Sheets.

3.5 Mounting Arrangements

- 3.5.1 The mounting arrangements shall be as specified on the Technical Data Sheets (i.e. flange mounted or remotely mounted).
- 3.5.2 If the actuator is mounted remotely from the valve, a suitable drive shaft shall be provided, incorporating all necessary universal joints, which shall be protected by gaiters. The design life of all drive shaft components shall be greater than or equal to that of the actuator. The actuator mountings/support structure shall accommodate any reaction forces that will occur when the valve is being driven.
- 3.5.3 In case the actuators have to be mounted in hazardous, inconvenient or difficult to reach positions, it shall be possible to separate the remote / local motor controls (including motor section) from the actuator; or, another (and identical) remote actuator control station shall be mounted separately. Regardless, it shall be possible to operate and configure the actuator remotely.
- 3.5.4 A wall bracket shall be included as an option and price to mount the remote controls / motor controls near the valve actuator.
- 3.5.5 If the remote actuator control section is mounted separately from the actuator motor section, the cabling between these two sections shall be included in the price for the actuator system. Power to the local actuator control section shall be taken from the actuator motor section; power from an another source shall not be allowed.
- 3.5.6 Actuator mounting flanges shall comply with BS EN ISO 5210 for multi-turn actuators and BS EN ISO 5211 for quarter-turn actuators.
- 3.5.7 The actuator shall be provided with an easily detachable drive coupling. Unless otherwise agreed with the Engineer, the coupling shall be supplied as a blank, for subsequent machining to suit the valve spindle or gearbox input shaft, as appropriate.

3.6 Rating Plate

- 3.6.1 The actuator shall be provided with an information plate permanently fixed to one of its major components. As a minimum, the information plate shall include the following information:
- a) Manufacturer and contact details
 - b) Model/type
 - c) Serial number
 - d) Valve reference number
 - e) Rated torque (Nm) at start-up and full load
 - f) Continuous rated output (kW)
 - g) Speed (rpm or secs/90°)
 - h) Frequency (Hz)
 - i) Power Factor;
 - j) Full load current (A) and starting current (A)
 - k) Flange reference
 - l) Actuator voltage and number of phases
 - m) Class of insulation
 - n) Lubricant
 - o) Year of manufacture

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- 3.6.2 Any additional information required on the information plate shall be as specified on the Technical Data Sheets.
 - 3.6.3 The plate and its fixings shall be manufactured from corrosion resistant, non-degradable metal materials and shall be indelibly stamped or engraved.
 - 3.6.4 The information contained on the rating plate shall be clearly accessible and visible after the motor has been painted.
 - 3.6.5 One set of spare engraved rating plates shall be provided with the installation.

3.7 Maintainability

- 3.7.1 All components that require regular inspection, cleaning or maintenance shall be readily and safely accessible and, where appropriate, easily replaceable.
- 3.7.2 As far as reasonably practicable, replacement parts shall be modular.
- 3.7.3 Components shall be uniquely and durably identified for ease of identification and replacement.
- 3.7.4 All fixtures and fixings shall be made of stainless steel (Grade A4 or equivalent).
- 3.7.5 Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearbox.
- 3.7.6 Each actuator shall be designed to facilitate maintenance. The coupling between the actuator and the valve or sluice gate shall be easily accessible. It shall be possible to do maintenance work on the actuator whilst the valve or sluice gate is in operation under local control.
- 3.7.7 Actuators required to take the valve opening and closing loads shall be designed to allow access to the actuator for inspection and maintenance without releasing the stem thrust or taking the valve out of service.
- 3.7.8 In order to minimise the amount of spare parts required, parts such as covers, plug / sockets etc. must be interchangeable throughout the model sizes installed, with reasonable similar frame sizes.
- 3.7.9 Electrical connection of actuators shall be made via switch disconnectors. Data connections shall be designed in order that disconnection of one actuator shall not disconnect the network.

4. ENVIRONMENT AND ENCLOSURES

4.1 Enclosure and Frame

- 4.1.1 The motor, reversing motor starter, control circuit transformer and all other control equipment shall be housed in a double sealed, common enclosure.
- 4.1.2 The minimum degree of ingress protection afforded by the enclosure shall be IP 68 (to SANS 60529) for multi turn actuators and IP67 for quarter turn actuators. The actual degree of ingress protection afforded by the enclosure shall be as stated on the Technical Data Sheets.
- 4.1.3 Adjustments to torque and position limit devices and configuration of indicator contacts shall be achieved by the method specified/stated on the Technical Data Sheets.
- 4.1.4 The actuators shall be adequately sealed and insulated to guarantee satisfactory operation under a submergence of 10,0 m of water.
- 4.1.5 All gearing, shaft bearings, torque limiting clutch mechanism limit switch assemblies etc. shall be totally enclosed and adequately lubricated.

4.2 Operating Environment

- 4.2.1 The operating environment of the actuator (including details of hazardous areas, EMC requirements etc.) shall be as specified on the Technical Data Sheets.
- 4.2.2 The actuator shall be capable of satisfactory operation within the ambient air temperature range -10°C to $+50^{\circ}\text{C}$ and up to a relative humidity of 95 %.
- 4.2.3 Any special hazards associated with the operating environment shall be as specified on the Technical Data Sheets.
- 4.2.4 All equipment selected for use in a hazardous area shall have undergone an appropriate conformity assessment procedure (CAP) to demonstrate compliance with the essential health and safety requirements.

4.3 Materials Selection

- 4.3.1 Materials shall be selected with proper reference to the specified operating environment and the design life of the actuator.

4.4 Corrosion Protection

- 4.4.1 All metallic components shall be designed and assembled to avoid galvanic corrosion. If necessary, insulating washers and sleeves shall be used to prevent direct contact between dissimilar metals.
- 4.4.2 Metal plating of ferrous materials, (e.g. zinc or cadmium plating) is not an adequate corrosion protection system for items such as actuator shafts and such items shall be provided with an additional coating of a semi setting, thick protective layer, such as a suitable Tectyl product, or equivalent.
- 4.4.3 Protection level KN shall be required as for installation in a low level of pollution concentration.

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- 4.4.4 The paint finish shall be appropriate to the operating environment and the design life of the actuator. Details of the paint finish shall be provided with the Tender. The paint colour shall be as specified on the Technical Data Sheets.

5. PERFORMANCE

5.1 Valve type and Duty

- 5.1.1 The valve type shall be as specified/stated on the Technical Data Sheets.
- 5.1.2 The valve stem or gearbox input shaft diameter shall be as specified/stated on the Technical Data Sheets.
- 5.1.3 Unless otherwise specified/stated on the Technical Data Sheets, the valve duty and number of cycles/starts per hour etc. shall be at least 600 starts per hour for modulating valve duty.
- 5.1.4 The maximum torque required to operate the valve (i.e. close, open or adjust position) shall be as specified/stated on the Technical Data Sheets.
- 5.1.5 The required valve stroke time (i.e. open to close) shall be as specified/stated on the Technical Data Sheets.
- 5.1.6 For rising spindle valves where the actuator is directly mounted onto the valve, the output shaft shall be hollow to accept the rising spindles.
- 5.1.7 For rising stem applications, the design must allow to removal of the actuator from the output drive without disturbing the function of the valve.
- 5.1.8 Each electric-motor-operated valve shall be fitted with suitable reduction gearing designed to unseat the valve under 75 % of the test pressure of the valve and to operate the valve while water is flowing through the valve at velocities up to 5.0 metres per second. Each operation from the full-open to the full-closed position or vice versa shall be completed within the time stated in the relevant schedules and shall be witnessed by the Engineer's representative at the suppliers works.

5.2 Design Life

- 5.2.1 Actuators shall be rated S4 to SANS 60034-1, 60 starts per hour at a rate not exceeding 600 starts per hour.

5.3 Rated Torque

- 5.3.1 The continuous actuator torque rating for regulating duty and for open/shut duty shall be at least 200 % of the start/opening or shut off torque, whichever is higher, specified by the valve manufacturer for this application (after any gearbox mechanical advantage has been taken into account).
- 5.3.2 The continuous actuator torque rating for actuators for modulating duty shall be at least 400 % of the valve requirement and the actuator shall be specifically designed for continuous modulation.
- 5.3.3 The safety margin on motor power available for seating and unseating shall be sufficient to ensure torque switch trip at maximum torque with a supply voltage +10/-6 % of the normal rated voltage.

5.4 Noise

- 5.4.1 Under all operating conditions, the noise levels from the actuator shall not exceed 75 dB(A) at a distance of 1 m from the actuator centre line (based on the actuator being mounted in 'semi-reverberant'/freefield conditions).
- 5.4.2 The sound power levels shall not exceed the values specified in SANS 10083.

6. DRIVE SYSTEM

6.1 General

- 6.1.1 Where the actuator operates gate valves or large diameter ball or plug valves, or for 'on-off' and 'inching' applications, the drive shall incorporate a lost motion 'hammer blow' feature (i.e. the motor shall reach maximum speed before engaging the drive). It shall also be possible to apply a 'hammer blow' effect manually via the handwheel.
- 6.1.2 For rising spindle valves, the output drive shaft shall be hollow to accept the rising spindle. Spindles that protrude above the actuator shall be enclosed in a fixed, impact resistant, transparent tube.
- 6.1.3 For quarter-turn actuators, adjustable mechanical stops shall be provided at 0° and 90°± 5°. These shall be easily adjustable from the outside of the actuator enclosure.
- 6.1.4 For modulating applications, lost motion between the worm wheel and drive shaft shall be eliminated, to minimise any hysteresis error.
- 6.1.5 All gearing shall operate with minimum gear backlash. The drive train shall be designed to prevent backlash.
- 6.1.6 The safety margin of motor power available for seating and unseating the valve shall be sufficient to ensure torque switch trip at maximum valve torque with the supply voltage 10 % below nominal.

6.2 Motor

- 6.2.1 All motors shall be specifically designed for valve-actuator operation which is characterised by high starting torque, low stall torque and low inertia.
- 6.2.2 Motors shall be of the non-ventilated totally enclosed type (TENV).
- 6.2.3 The electric motor shall be a totally sealed, 3-phase squirrel-cage induction type suitable for modulating continuous operating equipment to at least 4 times the sum of the opening and closing time specified in the scope of work. The motor shall have 4 poles or more.
- 6.2.4 Unless otherwise specified on the Technical Data Sheets, for 'on-off' and 'inching' applications, the motor shall be rated for 10 minutes at an average load of 33 % of rated torque for multi-turn actuators and 75 % of rated torque for direct quarter-turn actuators.
- 6.2.5 The motor shall have Class F insulation in accordance with SANS 60085 and shall be rated for a Class B (80 K) temperature rise. Temperature rise shall be measured by the embedded thermo switches in the windings during full load condition, in accordance with SANS 60034-1.
- 6.2.6 The motor shall be provided with suitable over-temperature and over-torque protection.
- 6.2.7 Motors must be totally separated from the lubricant-filled gearing of the actuator, allowing replacement of motor without losing any lubricant regardless of mounting position.

6.3 Motor Control

- 6.3.1 The actuator shall incorporate a suitably rated, reversing motor starter for three phase supplies.

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- 6.3.2 The reversing motor starter shall make use of reversing contactors. The contactors shall be mechanically and electrically interlocked.
- 6.3.3 The actuator shall be provided with stall protection that shall de-energise the motor if no movement is detected after receipt of a signal to open or close.
- 6.3.4 All contactors controlling the actuator motor shall be AC 3 duty rated with proper overload protection.
- 6.3.5 Solid-state motor starters shall be used for modulating duties where the number of starts/hour exceeds 600.
- 6.3.6 The motor starter shall provide the following features, as a minimum:
- a) Single phasing protection
 - b) Automatic phase rotation correction
 - c) Overload protection (torque trip protection)
 - d) Overvoltage protection
 - e) Motor over-temperature protection; and
 - f) Instantaneous reversal protection
- 6.3.7 Any additional features required/provided (e.g. jammed valve protection etc.) shall be as specified/stated on the Technical Data Sheets or suggested by the Manufacturer.

6.4 Integral Reduction Gearbox

- 6.4.1 The gearbox shall be of 'totally enclosed' design and shall be suitable for operation at any angle.
- 6.4.2 Unless specified otherwise in the Technical Data Sheets, oil-bath lubrication is preferred for the gearbox lubrication type.
- 6.4.3 No plastic on nylon gears will be accepted.
- 6.4.4 If specified on the Technical Data Sheets, the gearbox shall be 'sealed for life'. If sealed for life gearboxes are not required, oil lubricated, gearboxes shall be fitted with oil filling and drain points and an oil level indicator. The oil filling and drain points shall be designed so that oil can be easily drained and replaced without spillage.
- 6.4.5 Electrical and mechanical disconnection of the motor shall be possible without draining the lubricant from the actuator gearcase.
- 6.4.6 Gears shall not be subjected to thrust loads from the output shaft. Thrust loads shall be accommodated by a suitably positioned rolling element thrust bearing. The method of thrust bearing lubrication shall be as stated on the Technical Data Sheets.
- 6.4.7 It shall be possible to inspect and remove/replace gears without releasing the valve spindle thrust or taking the valve out of service.
- 6.4.8 Permanently sealed bearings are preferred.
- 6.4.9 In the case of electric actuators that operate through an intermediate gearbox between the valve and actuator a shear pin or other safety device shall be incorporated on one of the gears to prevent damage to the valve spindle and nut if excessive force is applied. Two spare pins shall be attached to each valve. The shear pin shall be designed to withstand the torque to unseat the valve at 75 % of the test pressure.

6.5 Second Stage Gearbox

- 6.5.1 If necessary, to meet the valve torque and/or stroke time requirements specified, a second stage gearbox shall be fitted to the actuator output shaft. If a second stage gearbox is provided, the gearbox specification shall be provided with the Tender.
- 6.5.2 The design of the gearbox shall meet the same standards of quality and finish as the actuator.
- 6.5.3 The gearbox shall be provided with an easily detachable drive coupling. Unless otherwise agreed with the Engineer, the coupling shall be supplied as a blank, for subsequent machining to suit the valve spindle.
- 6.5.4 If the gearbox is fitted to a quarter-turn actuator, adjustable mechanical stops shall be provided at 0° and $90^\circ \pm 5^\circ$. These shall be easily adjustable from the outside of the gearbox.

6.6 Manual Operation of Drive

- 6.6.1 The actuator motor shall have facility for being overridden for emergency shutting of the valve.
- 6.6.2 A handwheel shall be provided for manual operation of the valve, sized in accordance with BS EN 12570 and shall not move during motor operation.
- 6.6.3 Unless otherwise specified/stated on the Technical Data Sheets, the handwheel shall be engaged by declutching the motor drive with a lever or similar means and shall automatically and immediately disengage on restoration of the motor drive. The handwheel/lever shall not move on restoration of the motor drive. No damage to the actuator drive mechanism shall occur if manual operation is engaged while the motor is running. If a permanently engaged handwheel is required/provided, it shall be easily removable and/or designed to avoid injury to personnel during motor operation.
- 6.6.4 Handwheel gearing shall enable one person to manually open/close the valve without undue effort and in a reasonable time period, in accordance with BS EN 12570.
- 6.6.5 Unless agreed otherwise with the Engineer, clockwise operation of the handwheel shall close the valve.
- 6.6.6 The opening/closing direction shall be clearly and permanently indicated on the handwheel.
- 6.6.7 Provision shall be made for the lever engaging the motor to be padlocked to prevent unauthorised hand operation. Handwheels shall incorporate facilities for padlocking in the disengaged position.
- 6.6.8 The hand wheel shall incorporate an isolating mechanism to prevent it from turning when the valve is being power operated. A direction-of-rotation indicator shall be permanently attached to each hand wheel and a pointer attached to the shaft shall be weather-proof and of robust and rigid design; the embossed markings shall be large enough to be plainly visible from a distance of two metres. A drawing showing details of the indicator offered shall be submitted with the offer. If a detachable crank handle is offered the insertion of this handle shall operate a safety switch to cut off the electric power supply to the motor. The torque and limit switch shall be activated in manual operation of the actuator allowing a signal to be output once the set torque or set limit has been reached.
- 6.6.9 The actuator shall provide an impact effect to overcome tightly seated valves when the rotation direction of the handwheel is changed.



6.7 Extensions

- 6.7.1 Actuator extensions shall be designed generally in accordance with the drawings applicable to contract, specification or enquiry.
- 6.7.2 Where an actuator extension is present, identical flanged connections comprise the interface between valve and actuator extension and actuator extension and valve. Replacement gearboxes may require adapters between the valve flange and the gearbox input.
- 6.7.3 The actuator extension driving shaft shall be of stainless steel in accordance with BS 970 Gr. 431 S 29 (EN57).

7. WIRING AND TERMINALS

7.1 Wiring

- 7.1.1 All actuator wiring shall be contained within the main actuator enclosure. External conduit connections between components are not acceptable.
- 7.1.2 Internal wiring shall be PVC insulated. Cores shall be stranded or flexible.
- 7.1.3 Cables and cores shall be suitably identified at both ends.
- 7.1.4 All electrical equipment in the actuator shall be pre-wired and all external connections, including the relevant limit switches and any switches, which may be in excess of those specified, shall be wired to an easily accessible and clearly marked terminal block. The markings on the terminal blocks and the wiring shall correspond to those used on the wiring diagrams. Paper identification markings are not acceptable and non-fading plastic markers shall be provided. The terminal blocks shall be complete with all screws, nuts, washers and spring washers for connecting power and control cables to each terminal supplied.

7.2 Terminal Enclosure

- 7.2.1 All electrical components shall be wired to terminals, which shall be housed in a common terminal enclosure incorporated within the actuator housing. If specified on the Technical Data Sheets, the enclosure shall be incorporated within the actuator housing, but shall be separated from all internal actuator components by a watertight/dustproof seal, so as to provide ingress protection when the terminal enclosure cover is removed.
- 7.2.2 The number of cable entries in the terminal enclosure and the cable entry details shall be as specified/stated on the Technical Data Sheets. Cable entries shall be plugged during transit and storage with blanking plugs to prevent the ingress of moisture or foreign matter. Any conduit entries not used shall be plugged with threaded blanks and made water/gas tight using a suitable jointing compound.
- 7.2.3 Terminals shall be embedded in a terminal block of high tracking resistance compound and be of any approved type complying with SANS 60947-7.
- 7.2.4 Power and control circuit terminals shall be sized according to the relevant cable conductor cross sectional areas, subject to minimum conductor cross sectional area of 2.5 mm² and 1.5 mm² respectively. Power and control circuit terminals shall be adequately segregated.
- 7.2.5 A terminal identification schedule/diagram shall be fixed to the underside of the terminal enclosure cover. The diagram shall be printed on a durable material and include:
 - a) Serial number
 - b) External voltage values
 - c) Wiring diagram number; and
 - d) Terminal layout
- 7.2.6 The schedule/diagram shall allow space for the electrical installation Contractor to add cable identification details alongside the terminal numbers.
- 7.2.7 Wiring and schematic diagrams of the control circuit of each valve shall be provided. An installation and maintenance booklet shall be supplied with each valve actuator.
- 7.2.8 The compartment into which the cables are terminated shall be sealed from the balance of the actuator so that in the event of leakage through the cable gland no damage will occur to the actuator.

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- 7.2.9 Actuators shall be supplied-fitted with tapped steel plug seals in any open orifices or conduit entries. The use of plastic plugs for this purpose is not acceptable. This shall prevent flooding of electrical components prior to wiring up the actuator.

7.3 Earthing and Bonding

- 7.3.1 Actuator bonding facilities shall be as stated on the Technical Data Sheets.

8. CONTROL AND MONITORING

8.1 General

- 8.1.1 The actuator shall incorporate all necessary circuits (i.e. wiring, links, terminals etc.) and hand-operated control devices to enable effective local and remote operation.
- 8.1.2 Under both local and remote control, it shall be possible to reverse travel without the need for a separate stop signal.
- 8.1.3 If the opening or closing period is specified; e.g. to avoid water hammer; this period shall be achieved by incorporating a suitable gear ratio to allow the motor to operate continuously from fully open to fully closed; i.e. the motor shall not repeatedly stop and start over this period.
- 8.1.4 If however specified/stated on the Technical Data Sheets, under both local and remote control, it shall be possible to enable automatic pulsed operation, to extend valve opening/closing times and thereby avoid hydraulic shock.
- 8.1.5 Control of valves shall be by means of non-rising spindles unless otherwise specified.
- 8.1.6 An anti-condensation heater rated for the specified supply voltage shall be included in the switch compartment.
- 8.1.7 The actuator protection shall include phase rotation discrimination and single phasing protection.
- 8.1.8 If it is required that the actuator must close automatically when electrical supply fails, then a spring return or a suitably sized UPS shall be provided.

8.2 Control Circuit Transformer

- 8.2.1 Control circuit supplies shall be provided by a control circuit transformer that shall have the necessary tapplings and be adequately rated to provide power for the following functions:
 - a) Energising of the motor starter contactor coils, if necessary
 - b) Power supply for all local (internal) indication/monitoring circuits (24 V DC supply); and
 - c) Power supply for all remote (external) indication/monitoring circuits, if necessary (24 V DC supply)

8.3 Local Control and Indication

- 8.3.1 Local Control
 - a) The actuator shall incorporate the following externally mounted hand-operated control devices:
 - i) A 'Local/Off/Remote' mode selector switch; and
 - ii) A rotary switch or push-buttons to open/close/stop the actuator in 'Local' mode.
 - b) With respect to item a), the selector switch shall be padlockable in any mode and be capable of accepting a 30 mm x 6 mm diameter padlock shackle.
 - c) It shall be possible to configure local control for maintained or push-to-run (inching) operation.
 - d) All controls shall be marked as to their function with easy-to-read, durable labels that are permanently inscribed or embossed.

- e) The controls shall form an integral part of the actuator and shall be non-intrusive.
- f) It shall be possible to rotate local controls through 90° increments to suit the actuator orientation. The local control section shall be capable of being in the upright position independent of the valve and actuator orientation.
- g) All built-in protection devices shall still be active during Local operation of the actuator.

8.3.2 Local Indication

- a) Local indication of valve position by means of a back lit liquid crystal display or mechanical indicator giving position indication.
- b) Electronic displays shall be capable of maintaining and updating valve position data on loss of external power to the actuator.
- c) Mechanical indication shall be continuous in relation to valve movement.
- d) LED indicators shall be provided to indicate whether the valve is fully open, fully closed or in an intermediate position. The colours of the LED indicators and their meanings shall be as specified/stated on the Technical Data Sheets.
- e) If specified/stated on the Technical Data Sheets, valve, actuator and control system status information (e.g. reporting of specific types of fault) shall be available local to the actuator.
- f) It shall be possible to rotate local indicators through 90° increments to suit the actuator orientation. The local display shall be capable of being in the upright position independent of the valve and actuator orientation.

8.4 Remote Control and Monitoring

8.4.1 Remote Control

- a) The control circuit supply details shall be as specified/stated on the Technical Data Sheets (i.e. internal 24 V DC supply and/or external supply (240 V AC)).
- b) The actuator shall incorporate all necessary circuits (wiring and terminals etc.) to provide the following remote control functions, as a minimum:
 - i) Open/Stop/Close (maintained), 4 wire control
 - ii) Open/Close (maintained), 3 wire control, mid-travel reversal; and
 - iii) Open/Close (non maintained i.e. 'push to run' (inching)), 3 wire control
- c) Any additional functions required/provided (e.g. emergency shutdown to open or close the valve or maintain position, etc.) shall be as specified in the Particular Specification.
- d) If specified on the Technical Data Sheets, the actuator shall be provided with a two-wire 4-20 mA positioner to enable it to respond to an analogue input signal to vary valve position. Unless otherwise specified on the Technical Data Sheets, 4 and 20 mA shall correspond to the fully closed and fully open positions respectively. Unless otherwise specified on the Technical Data Sheets, the repeatability of the controller shall be within 1.0 %.
- e) Opto-isolated devices shall be provided to interface the actuator internal circuits with the remote controls.

8.4.2 Remote Monitoring

- a) Unless specified otherwise in the MCC Table, the output signals required/provided shall be for the indication of fully open, fully closed and intermediate position.
- b) Output signals shall be provided by a monitor relay with a volt-free changeover contact and an appropriate number of latching, volt-free, single-pole contacts, configurable to be either 'normally open' or 'normally closed'. Position signals shall remain available

and updated during loss of mains power supply. Contacts shall be rated at 5 A, 30 V DC/240 V AC.

- c) If specified/stated on the I/O list, the actuator shall incorporate a device to provide a 4-20 mA analogue signal proportional to valve position.
- d) If specified/stated on the I/O list, the actuator shall incorporate a device to provide a 4-20 mA analogue signal proportional to actuator output torque.
- e) If specified/stated on the Technical Data Sheets the actuator shall be suitable for remote control and monitoring via a fieldbus system. The communications protocol shall be as specified/stated on the Technical Data Sheets.
- f) An indication light shall be provided on the panel to indicate whether the actuator is switched in 'Local/Off/Auto' setting.
- g) Indication lights shall be provided on the panel to indicate whether the valve is fully open, fully closed or in an intermediate position. The colours of the LED indicators and their meanings shall be as specified/stated on the Technical Data Sheets.
- h) Five additional potential free contacts programmable by the user to indicate functions such as high torque, thermostat tripped and remote selected.
- i) Actuators supplied with internal batteries for memory back-up purposes shall have battery facilities with a potential free contact.
- j) For modulating valves, information pertaining to intermediate valve position and torque on output shaft shall be fed back to the control system and shall be indicated on the SCADA.

8.5 Disconnecting Device

- 8.5.1 Each actuator shall have one easily accessible (within arm's reach) IP68 rated electrically disconnecting device to disconnect the entire actuator installation from the electrical power supply.
- 8.5.2 The disconnecting device is intended for repair, maintenance and/or inspection and shall have at least the safety isolating requirements of a switch-disconnector.
- 8.5.3 The switch-disconnector shall be mounted within arm's reach from the terminals of the appliance and shall be padlockable.
- 8.5.4 The switch-disconnector shall disconnect all phase conductors but need not disconnect the earth conductor.

8.6 Diagnostics

- 8.6.1 The actuator shall incorporate a diagnostic module that will store and enable download of historical actuator operation and torque data to permit analysis of actuator and valve in-service performance. Data shall be available locally or remotely via telecom data transfer. Diagnostic and configuration software shall be made for user PC and PDA (personal digital assistant) systems.

8.7 Torque and Position Limit Devices

- 8.7.1 The actuator shall incorporate torque and position limit devices, selectable in any combination, for the setting of open and close limits (e.g. it shall be possible to stop valve travel in the 'fully closed' position by torque limitation to ensure proper seating of the valve, with the 'fully closed' position limit devices adjusted to be inoperative).
- 8.7.2 The torque limit device shall trip the motor starter if the actuator is overloaded due to the valve being obstructed or jammed. However, it shall be possible to inhibit the torque limit protection system for parts of the valve travel adjacent to the closed and open limit positions

to aid valve seating/unseating. In addition, it shall be possible to inhibit torque protection during starting/reversing in mid-travel against high inertia loads.

- 8.7.3 Torque and position limit devices shall be easily and accurately adjustable within the ranges 40-100 % rated torque and over the full range of valve travel. It shall be possible to adjust position limit devices in a safe manner without coming into contact with live terminals.
- 8.7.4 All position limit devices shall function correctly when the actuator is operated manually (e.g. during isolation).
- 8.7.5 If specified on the Technical Data Sheets, a number of additional sets of position limit devices shall be provided to enable an additional switching point to be set for each direction of rotation (e.g. to signal a certain valve position or start/switch off any related item of plant).
- 8.7.6 The electrical circuit diagram of the actuator shall not vary with valve type; remaining identical regardless of whether the valve is to open or close on torque or position limit.
- 8.7.7 For high speed applications, torque limiting brakes shall be supplied to prevent excessive valve seat loading.

8.8 Control Signal Facilities

- 8.8.1 The various actuators shall either be equipped with a mechanism by which either an analogue 4 - 20 mA signal is generated in proportion to the status of the valve or sluice gate setting to facilitate proportional control, or the actuators shall be actuated by a digital signal which causes them to open fully or close fully.
- 8.8.2 The two types of electric actuator shall have the following control/signal facilities (type A = open/close, type B = modulating):
 - a) Open/Closed Valve
 - i) Open coil - 240 V AC - Facilities to open the valve by means of a potential free contact.
 - ii) Close coil - 240 V AC - Facilities to close the valve by means of a potential free contact.
 - iii) Potential free contact to signal that the valve is open.
 - iv) Potential free contact to signal that the valve is closed.
 - v) Potential free change over contact to signal local "Local/Off/Remote" selection.
 - b) Modulating Valve
 - i) Position signal: 4 - 20 mA.
 - ii) Position feedback: 4 - 20 mA.
 - iii) Potential free changeover contact to signal local "Local/Off/Remote" selection.

9. DRAWINGS AND DOCUMENTATION

9.1 General

- 9.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with the Employer's name and project / scheme / contract reference title and numbers, the Employer's representative's name and reference numbers, and the Manufacturer's works / contract / order references.

9.2 Drawings

- 9.2.1 Detailed "as-built" drawings shall be provided by the Contractor showing positions of the actuators and cable routes.
- 9.2.2 Sufficient details will be given on the drawings to enable replacement parts to be made locally.

9.3 Drawings and Documentation for Approval by the Engineer

- 9.3.1 The following documentation and drawings shall be submitted to the Engineer:
- a) Prior to procurement
Detailed actuator list including tag number, supplier, location, failsafe positions signal and communication.
 - b) Prior to installation
Hook-up and loop drawings

9.4 Operating and Maintenance Manual

- 9.4.1 Three fully indexed Operation and Maintenance Manuals and three Certification copies shall be provided for all motors supplied. A draft copy shall be submitted to the Engineer for approval. The operating and maintenance manuals shall include at least the following (manual's format shall be of A4):
- a) A schedule of all components equipment in the installations with the following information shall be provided:
 - i) Manufacturers name and contact details
 - ii) Actuator tag number
 - iii) Function (e.g. 'Sludge Valve')
 - b) Full description and details of design capacity and design criteria for each item of equipment and each product.
 - c) Procedures for fault finding.
 - d) Maintenance instructions for all actuators and components and including repair, overhaul, change-out and installation procedures.
 - e) All special tools required for the maintenance and overhaul of all the equipment shall be listed.
 - f) Details of the maintenance tasks and schedules required to achieve the specified actuator asset life.
 - g) A schedule giving the complete list of spares which should be ordered.



9.5 Information to be Supplied with Tender

- 9.5.1 A set of complete Technical Data Sheets from the actuator Manufacturer for every type of actuator provided.
- 9.5.2 A general arrangement (GA) drawing of the actuator indicating the designation, overall dimensions/footprint and typical layout of key components/systems.
- 9.5.3 A lubrication schedule detailing all components/systems requiring lubrication, the method and frequency of lubrication and the type and manufacturer of the lubricants.
- 9.5.4 A schedule of spares required for 2 years of normal operation (plus associated costs, lead times, supplier or local agent contact details).
- 9.5.5 Motor speed/toque curves.

10. TESTING AND COMMISSIONING

10.1 General

- 10.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.
- 10.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.
- 10.1.3 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.
- 10.1.4 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Contract Conditions, the period of notice for witness testing shall be 5 working days.
- 10.1.5 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.
- 10.1.6 Unless otherwise agreed by the Engineer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

10.2 Inspection and Test Sequence

- 10.2.1 Factory Acceptance Testing (FAT)
 - a) Each actuator shall be performance tested at the Supplier's Works. Reports of actuator type testing shall be made available to the Engineer, on request.
 - b) The test equipment shall simulate a typical valve load and the following parameters shall be recorded:
 - i) No Load Current
 - ii) Motor current at maximum torque setting
 - iii) Actuator torque at maximum torque setting
 - iv) Test voltage and frequency
 - v) Flash test voltage
 - vi) Actuator output speed or operating time; and
 - vii) Actuator stall torque
 - c) A test certificate shall be provided free of charge. In addition to the parameters listed above, the test certificate shall record design details such as gear ratios for manual and automatic operation (including any details of second stage gearing, if provided), drive closing direction and wiring diagram number.
- 10.2.2 Inspections Before Testing

Before testing, inspections shall be performed to verify:

- 
- a) all equipment and material is of the correct type and complies with applicable SANS and IEC standards
 - b) all parts of the installation are correctly selected and erected
 - c) no part of the installation is visibly damaged or otherwise defective
 - d) the installation is suitable for the environmental conditions; and
 - e) the installation complies with this Specification

10.2.3 Tests before supply is connected

On satisfactory completion of the inspections specified and before the supply is connected, the following tests shall be undertaken in the sequence listed:

- a) Continuity of conductors:
 - i) Earthing conductor
 - ii) Main bonding conductors
- b) Insulation resistance:
 - i) Site applied insulation, where applicable
- c) Protection by separation of circuits, where applicable
- d) Protection by barriers or enclosures provided during erection, where applicable
- e) Insulation of non-conducting floors and walls, where applicable
- f) Polarity
- g) Earth electrode resistance, where applicable

10.2.4 Tests after supply is connected

On satisfactory completion of the tests specified and after connection of the supply, the following additional tests shall be performed in the sequence listed.

- a) Re-check of polarity
- b) Phase rotation, unless otherwise ascertained

10.2.5 A final inspection record shall be supplied with each actuator. This shall include the following information:

- a) General actuator data
- b) Nominal current
- c) No load current
- d) Starting current
- e) Power factor at rated torque
- f) Output speed
- g) Torque switch setting
- h) Limit switch setting (turns/stroke)
- i) High voltage test
- j) Functional test (including all options)
- k) Visual test



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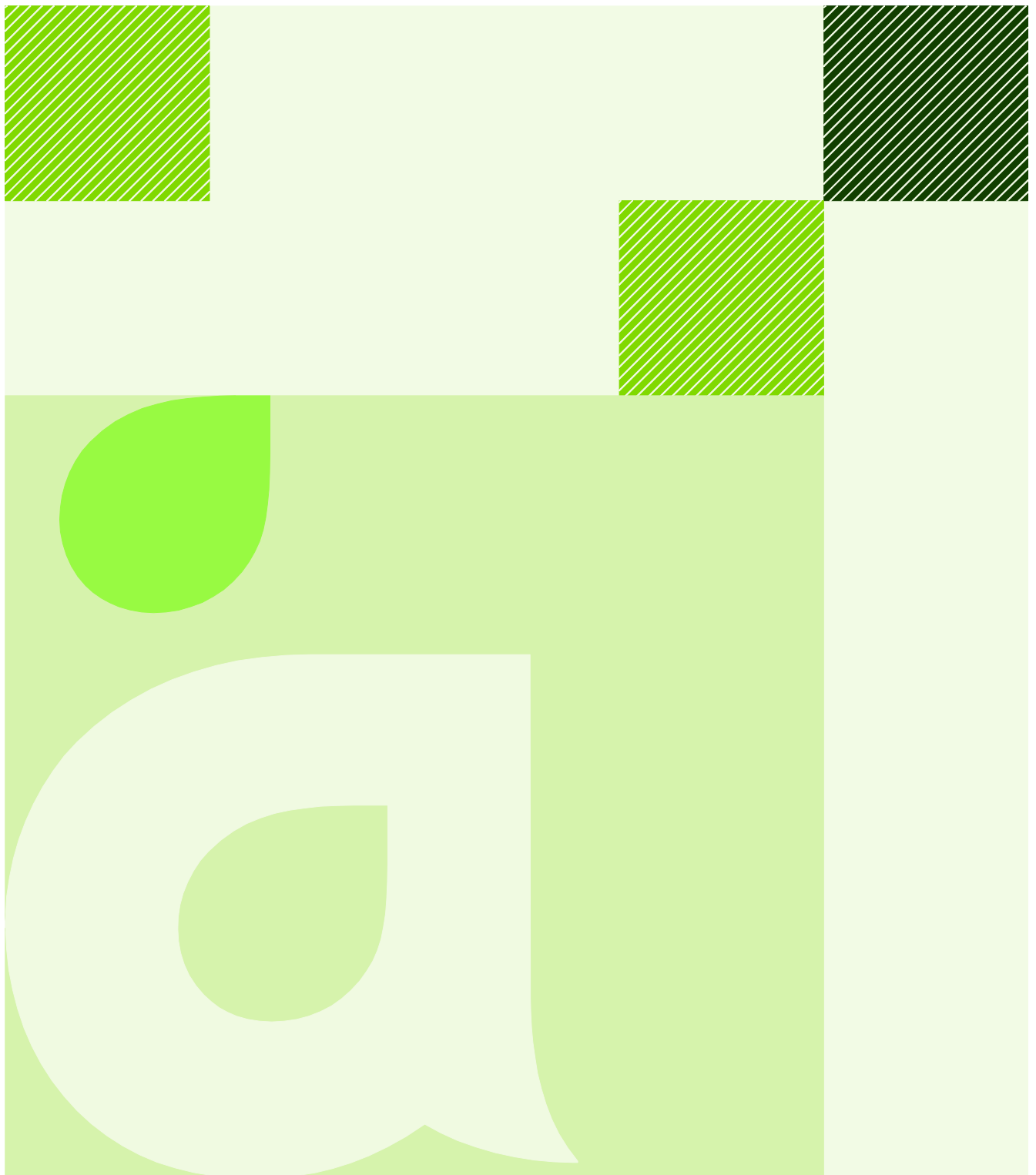
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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.
- 1.1.2 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.
- 1.1.3 Note however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also, that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, thorough reference must be made to the relevant statutory documentation.

1.2 Electrical System Characteristics

- 1.2.1 The design of the installation shall comply with SANS 10142-1.
- 1.2.2 The design of the installation shall consider the following supply characteristics:
 - a) Voltage, frequency and number of phases
 - b) Maximum prospective short circuit current (phase to phase and phase to neutral)
 - c) Type of system, e.g. TN-S, TN-C-S
 - d) Maximum earth loop impedance of the earth fault path external to the installation
 - e) Type and rating of the cut-out or switch device
 - f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment
- 1.2.3 The installation protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.
- 1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and working space for such activities. Similarly, the positioning of equipment shall not impede access to, or working space at, non-electrical equipment and services for operation and maintenance activities.
- 1.2.5 The installation shall be suitable for access and use by electrically unskilled persons.
- 1.2.6 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.
- 2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.
- 2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the Installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:
- a) Occupational Health and Safety Act (Act 85 of 1993)
 - b) Construction Regulations 2003 issued in terms of Section 43 of the Act
 - c) Local Fire Regulations; and
 - d) Regulations of the Local Supply Authority
- and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 32	Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants
SANS 97	Electric cables – Impregnated paper insulated metal-sheathed cables for rated voltages 3,3/3,3 kV to 19/22 kV (excluding pressure assisted cables)
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1063	Earth rods, couplers and connections
SANS 1085	Wall outlet boxes for the enclosure of electrical accessories
SANS 1088	Luminaire entries and spigots
SANS 1091	National colour standards of Paint
SANS 1195	Busbars
SANS 1213	Mechanical cable glands
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1266	Ballasts for discharge lamps (excluding tubular fluorescent lamps)

Standard Number	Description
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1431	Weldable structural steels
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1700	Fasteners
SANS 1777	Photoelectric control units for lighting
SANS 1783	Sawn softwood timber
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 2001	Construction Works
SANS 10155	Accuracy in buildings
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10177	Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400	The application of the National Building Regulations
SANS 60269	Low-voltage fuses
SANS 60309	Plugs, socket-outlets and couplers for industrial purposes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
SANS 60669	Switches for household and similar fixed-electrical installations
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
SANS 61048	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(U _m = 36 kV)
SANS 61643	Low-voltage surge protective devices
Other Standards	Description
ARP 035	Guidelines for the installation and maintenance of street lighting
BS 88	Specification of supplementary requirements for fuses of compact dimensions for use in 240 / 415 V industrial and commercial electric installations
IEC 157	Low voltage switchgear and control gear
IEC 408	Low voltage air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units
IEC 12373	Aluminium and aluminium alloys. Anodizing. Method for specifying decorative and protective anodic oxidation coatings on aluminium
IEC 50086	Conduit systems for cable management
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations

2.2.2 Standards are often tailored to the conditions of their country or origin (in terms of permissible voltages, expected ambient temperatures, etc.). Therefore, and unless normatively referenced to the contrary in a Standard of higher precedence, the decreasing order of precedence of Standards shall be:

- a) South African National Standards (SANS, VC, etc.)

- 
- b) South African Sectoral Standards and Specifications (NERSA, CKS, ARP, NRS, PIESA, etc.)
 - c) ISO Standards
 - d) IEC Standards
 - e) Harmonized British Standards (BS EN)
 - f) Other Harmonized European National (EN) Standards (CEN, CENELEC, ETSI)
 - g) Non-Harmonized British Standards (BS)
 - h) Other international standards

2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

- a) This Specification, including all Technical Data Sheets; and
- b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. COMPONENTS AND EQUIPMENT

3.1 Lighting and Accessories

3.1.1 Luminaires

- a) Luminaires shall comply with SANS 60598 (relevant parts).
- b) Luminaires shall be supplied complete with lamps of a type suitable for the luminaire design.
- c) Upon the Engineer's request, simulation data files must be made available for each luminaire.

3.1.2 Control Gear and Enclosures

High frequency, electronic control gear shall be used for tubular (double capped) and compact (single capped) fluorescent lamps, and, where appropriate, for discharge lamps.

3.1.3 Switches

- a) Flush mounted switches
 - i) Flush mounted switches shall comply with SANS 60669-1 and shall bear the SABS mark.
 - ii) All flush mounted switches shall be suitable for mounting in 100 x 50 x 50 mm galvanised steel or PVC wall boxes.
 - iii) The switch mechanism shall be of the tumbler-operated micro-gap type with silent operation, and shall be rated for 16 A continuous loading at 50 Hz and 250 V.
 - iv) 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.
 - v) 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) Cover plates for switches
 - i) Cover plates for flush mounted switches shall have levelled edges which overlap the wall box in order to conceal all wall imperfections.
- c) Surface mounted switches
 - i) Surface mounted switches shall comply with SANS 60669-1 and shall bear the SABS mark.
 - ii) 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.
 - iii) The switch mechanism shall be of the tumbler operated micro-gap type with silent operation and shall be rated for 16 A continuous loading at 250 V and 50 Hz.
 - iv) A brass earthing terminal shall furthermore be provided on the switch construction to ensure the positive earthing of the switch assembly and enclosure.
 - v) The covers of surface mounted switches shall have toggle protectors.

d) Photo-Electric daylight switches

- i) The unit shall comprise a photo-cell, thermal actuator and change-over switch. The cover of the unit shall be manufactured from a tough, durable material providing protection against tampering. The cover shall have good weathering properties. It shall be ultra violet resistant and shall not deteriorate when exposed to sunlight for prolonged periods.
- ii) The units shall be capable of operating in dusty conditions, and over an ambient temperature range - 15 °C to + 55 °C.
- iii) The units shall be designed to withstand damage by hail and stones thrown by vandals. If the units do not possess this quality, separate wire screens shall be provided for this purpose.
- iv) All parts shall be treated to be corrosion-proof.
- v) The operation level shall be factory pre-set for "ON" at a light level of 60 lux and "OFF" at 90 lux, with a permissible deviation of 12 lux either way. Voltage variations shall not materially affect the operational levels.
- vi) A time delay, of not less than 15 seconds, shall be provided to prevent the unit from functioning due short-duration changes in illumination, such as lightning.
- vii) The unit shall be effectively safeguarded against voltage surges by means of a suitable surge protector, which shall preferably form an integral part of the unit.
- viii) The unit shall be of the wall mounting type and shall be supplied complete with a suitable bracket.
- ix) The change-over switch shall be capable of switching 10 A AC at 250 V.

e) Dimmer modules

- i) Dimmer modules shall comply with SANS 60929.
- ii) Units shall be rated at 250 V, and capable of powering inductive (minimum power factor of 0.65 lagging) and capacitive (minimum power factor of 0.75 leading) loads.
- iii) The efficiency of modules may not be less than 95 %, and the harmonic current injection not more than 1 % THD, at full load (where such load is resistive).
- iv) Furthermore, the units shall be provided with automatic over-temperature, over-current and short-circuit cut-out features. Where over-current of short duration is expected (i.e. luminaire starting current), over-current protection may be by way of self-regulation (i.e. a reduction in output voltage).
- v) Dimmer modules shall be sound-attenuated, such that audible noise is limited to 30 dB (all weightings) measured at a distance of 1 m from the module.
- vi) The output of modules shall be controlled by propriety pushbutton-type switches. An additional switch, located in the same enclosure as the pushbutton, shall be provided for switching the input to the dimmer module.
- vii) Unless prior approval in this regard has been gained from the Engineer, dimmer modules may not be paralleled.
- viii) Dimmer modules shall be selected and installed such that 30 % spare capacity will be available for future additions to the output circuitry.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 Installation of Lighting and Accessories

4.1.1 Mounting of light fittings

- a) Surface mounted down light holders, such as the bayonet / screw-in type lamp holders used for incandescent fittings, shall be screwed to the ceiling by means of at least two 4 mm diameter self-tapping screws. Plastic expansion plugs, of good quality, are to be used where the surface is concrete, plaster or brick. For suspended and soft ceilings, a solid timber backing strip of at least 40 x 40 mm timber must be supplied and installed between supports, with the screws fixed to these backing strips.
- b) Channelled fittings, such as fluorescent fittings, shall be firmly mounted to ensure close contact with the ceiling over the entire length of the fitting. 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. Where fittings are to be installed underneath suspended ceilings, they shall be mounted in an equal manner, but timber backing strips of at least 40 x 40 x 450 mm (at both ends) shall be placed in position on top of the ceiling board and the end screws secured to these strips, such that the weights of the fittings distribute evenly.
- c) To ensure the safety of people below, where fittings are clamped or bolted directly to trusses or other building elements (as in the case of some high bay and floodlight installations) they shall be provided with an additional safety chain or safety cable of appropriate corrosion-proof material. This safety cable / safety chain assembly shall be connected independently of the luminaire-supporting clamps or bolts, such that either assembly can be loosened and removed without affecting the other. The safety assemblies shall have a load safety factor not less than 3.
- d) Specialized light fittings (i.e. types of fittings not mentioned in this specification) must be installed strictly in accordance with their manufacturer's requirements and guidelines.

5. DRAWINGS AND DOCUMENTATION

5.1 General

5.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

- a) The Client's name and contact details
- b) Client's project / scheme / contract reference title and numbers
- c) The Engineer's name and contact details
- d) Engineers reference numbers
- e) Contractor's works / contract / order references.

5.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

5.2 Drawings for Approval

5.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

- a) Cable route layout drawings showing:
 - i) Type of wireways
 - ii) Trenching
 - iii) Cable junction boxes

5.3 As-built Drawings

5.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

- a) Equipment (e.g. light fittings, draw boxes, outlets etc.)
- b) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and
- c) Cable routes (including any cable joints)
- d) General arrangement drawings
- e) Single Line Diagrams

5.4 Operating and Maintenance Manual

5.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

5.4.2 The operating and maintenance manuals shall include at least the following:

- a) A schedule of installed components and equipment, containing the following information:
 - i) Manufacturers name and contact details
 - ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

- 
- iii) Function (e.g. switching lighting circuit DB03-L1)
 - b) A schedule of all installed cables, with the following information:
 - i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)
 - ii) Size
 - iii) Installed length; and
 - iv) Function (e.g. "Feeding Submersible pump IW-SP-01")
 - c) Description and details w.r.t:
 - i) Detailed description of the function of all operator controls
 - ii) Procedures for fault finding
 - iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures
 - iv) Inspection schedules; and
 - v) Spare part information and recommended spares

6. TESTING AND COMMISSIONING

6.1 General

- 6.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.
- 6.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.
- 6.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.
- 6.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.
- 6.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.
- 6.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.
- 6.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.
- 6.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.
- 6.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

6.2 Test Sequence

6.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

- a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards
- b) All parts of the installation are correctly selected and erected
- c) No part of the installation is visibly damaged or otherwise defective
- d) The installation is suitable for the environmental conditions; and
- e) The installation complies with this Specification

6.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 6.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

- a) Continuity of conductors

- 
- b) Resistance of Earthing conductor
 - c) Continuity of ring circuits Earth fault loop impedance at main switch
 - d) Elevated voltage on supply neutral Earth Resistance
 - e) Insulation resistance
 - f) Voltage, main distribution board - no load
 - g) Voltage, main distribution board - on load
 - h) Voltage at available load
 - i) Operation of earth leakage units
 - j) Earth leakage test button
 - k) Polarity at points of consumption
 - l) Switching devices



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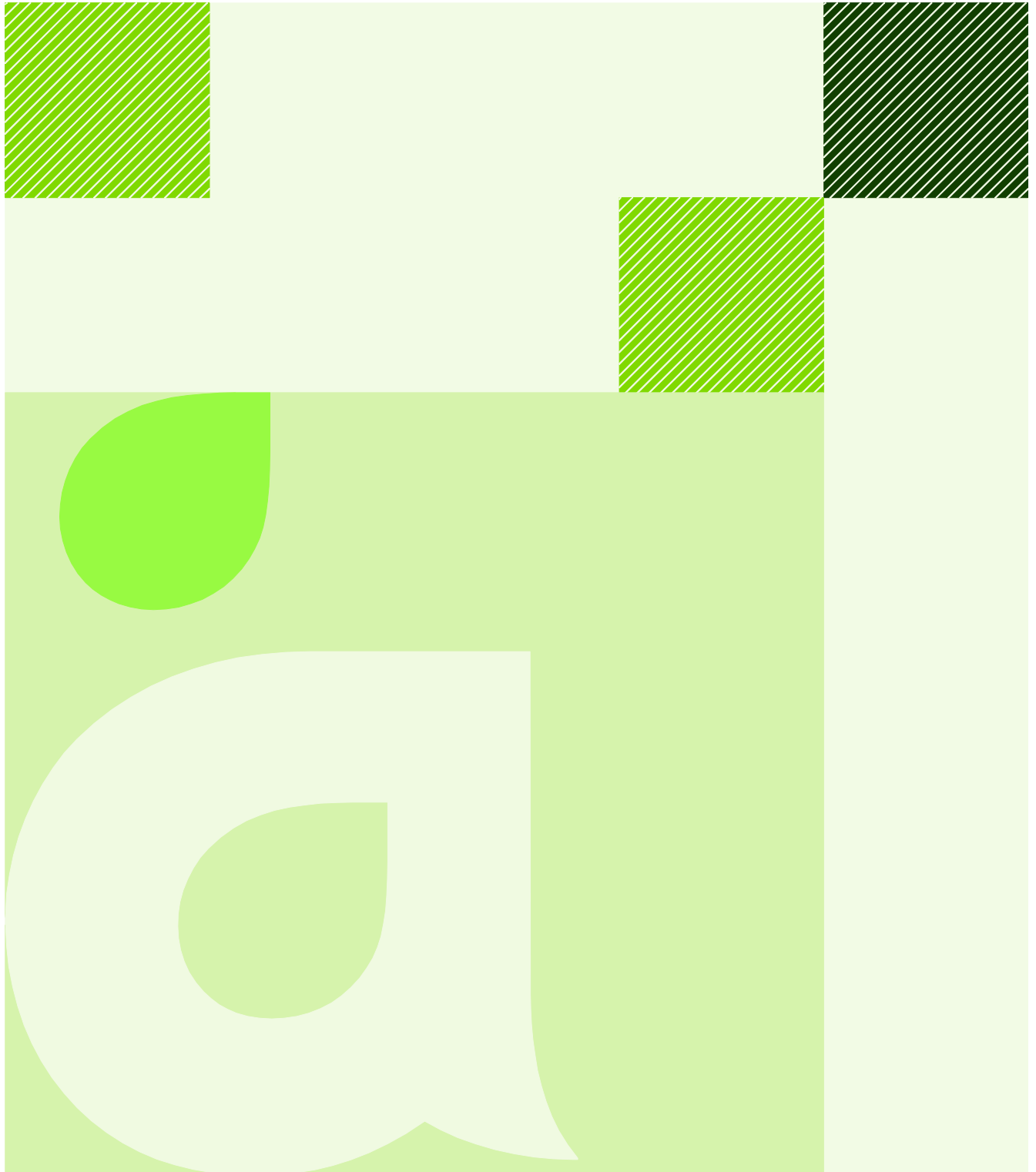
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Low Voltage Cables

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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the supply, delivery to site, site installation, site testing, commissioning and handover of Low Voltage cable systems.
- 1.1.2 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.
- 1.1.3 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.
- 1.1.4 Note, however, that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, SANS 1411.

1.2 Electrical System Characteristics

- 1.2.1 The design of the installation shall comply with SANS 10142-1.
- 1.2.2 The design of the installation shall consider the following supply characteristics:
 - a) Voltage, frequency and number of phases
 - b) Maximum prospective short circuit current (phase to phase and phase to neutral)
 - c) Type of system, e.g. TN-S, TN-C-S
 - d) Maximum earth loop impedance of the earth fault path external to the installation
 - e) Type and rating of the cut-out or switch device
 - f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment
- 1.2.3 The installation of protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.
- 1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and adequate working space for such activities.
- 1.2.5 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.
- 2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.
- 2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:

- a) Occupational Health and Safety Act (Act 85 of 1993)
- b) Construction Regulations 2003 issued in terms of Section 43 of the Act
- c) Local Fire Regulations; and
- d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1 Reference Standards

Standard Number	Description
SANS 1213	Mechanical cable glands
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
IEC 50086	Conduit systems for cable management

- 2.2.2 The installation shall also comply with:
- a) This Specification, including all Technical Data Sheets; and
 - b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.



3. GENERAL

3.1 General

- 3.1.1 Cables shall be manufactured strictly in accordance with SANS 1507.
- 3.1.2 Cables shall be delivered within 12 months of manufacture and shall be delivered to site on cable drums or coiled with protective wrappings.
- 3.1.3 Cables shall be delivered, stored and handled in accordance with the manufacturer's instructions. Where the performance of the cable is likely to be adversely affected by the ingress of moisture, it shall be adequately sealed at both ends
- 3.1.4 The end protruding from the drum shall be protected against mechanical damage.
- 3.1.5 Cable selection and sizing should comply with SANS 10142-1. Cables and their wireways shall, where required by SANS 10400 Part T to be protected against the effects of fire, be selected and installed in accordance with the provisions of such code.
- 3.1.6 Cables shall have copper or aluminium conductors according to SANS 1411-1. Cores of cross sectional area greater than 1,5 mm² shall be stranded or flexible.
- 3.1.7 Where neutral conductors are to be provided, they shall be of the same cross sectional area as the associated phase conductor, unless otherwise specified in the Particular Specification and drawings.

4. LOW VOLTAGE CABLES

4.1 Types of Low Voltage Cables

- 4.1.1 Unless otherwise specified, all LV cables shall have copper conductors to SANS 1411-1. Cores of cross sectional area greater than $1,5 \text{ mm}^2$ shall be stranded or flexible. Where neutral conductors are to be provided, they shall be of the same cross sectional area as the associated phase conductor, unless otherwise specified in the design documentation and drawings.
- 4.1.2 All LV cables used in an electrical installation shall be as specified in the Particular Specification (or cable schedule as part of the Particular Specification) and shall comply with either of the following:
- a) PVC/AWA/PVC and PVC/SWA/PVC
 - i) Cables shall comply with SANS 1507-3 and be rated at 600/1000 V.
 - ii) Single core cables shall have aluminium wire armouring.
 - iii) Multicore cables comprising five conductors and above shall have each core individually coloured, or, where not available, be coloured white with phase identification in black numerals.
 - b) XLPE/AWA/PVC and XLPE/SWA/PVC
 - i) Cables shall comply with SANS 1507-4 and be rated at 600/1000 V.
 - ii) Single core cables shall have aluminium wire armouring.
 - c) PVC/PVC
 - i) Cables shall comply with SANS 1507-3 and be rated at 600/1000 V.
 - d) XLPE/PVC
 - i) Cables shall comply with SANS 1507-4, and be rated at 600/100 V.
 - e) Single Core PVC
 - i) Cables shall comply with SANS 1507-2 and be rated at 600/1000 V.
 - ii) The insulation shall be phase coloured, and, where used in single phase systems, line cables shall be red, neutral cables black and earth cables yellow and green.
 - f) Flat Twin and Earth PVC
 - i) Copper conductors shall comply with SANS 1411-1, PVC insulated to SANS 1411-2, laid up with a bare copper earth continuity conductor between them, with PVC bedding to SANS 1411-2.
 - ii) Cables shall be rated at 300/500 V.
 - g) Fire Resistant Cables
 - i) Cables requiring protection against the effects of fire shall be of fire-resistant construction (note here that “fire-rated” cables are not the same as “fire-resistant” cables).
 - ii) Fire-resistant cables shall thus comply with SANS 60331-21 and / or BS EN 50200.

- 
- iii) Except where prior approval in this regard has been granted by the Engineer, increasing the resistance to fire of normal (i.e. non-fire resistant) cables though the application of a coat of fire-resistant compound will not be accepted.

4.2 Cable Accessories

4.2.1 Cable Markers

Concrete markers for the indication of cable or trench routes shall be placed at a minimum of 50 m intervals, changes in trench or cable direction and at road crossings. The markers shall protrude by 25 mm above finished ground level, except where they are likely to cause obstruction, when they shall be laid flush with the finished ground level.

5. INSTALLATION OF CABLES

5.1 General

- 5.1.1 The cable installation shall comply with the requirements of SANS 10142-1.
- 5.1.2 Cables shall be installed strictly in accordance with the cable route drawings.
- 5.1.3 Cables installed in groups shall run in straight lines and not cross over each other, except where transposing of cables is required to reduce capacitive or inductive effects.
- 5.1.4 Cables installed above ground shall, as far possible, run parallel with the lines of building construction. Cables and wireways shall then only be installed in horizontal and vertical runs, and the installation shall be as visually unobtrusive as possible.
- 5.1.5 Cables buried below ground shall, as far as possible, follow features of the site such as roadways and building lines.
- 5.1.6 Where a redundant cable installation is required, the cables shall not be installed along the same route, and their routes shall be through separate fire compartments (except where no separation occurs, as may be the case in the vicinity of the source and load).
- 5.1.7 Cables and their support systems shall not be fixed to protective barriers, guards or directly to guard-rails.
- 5.1.8 Cables shall not be exposed to direct sunlight after installation. If the cable route compels the support system to be in direct sunlight, the Contractor shall ensure cables are covered with a suitable canopy or cover of the same material as the support system (tray). Cables shall be installed strictly according to the manufacturer's requirements pertaining to:
 - a) Maximum tensile or compressive stresses (e.g. due to pinching or squashing)
 - b) Minimum bending radii
 - c) Temperature of installation; and
 - d) Operating environment
- 5.1.9 No joints or repairs to outer sheathings or insulation shall be allowed in low-voltage cables without the prior approval of the Engineer.
- 5.1.10 Propriety (i.e. suited to and manufactured for such use) cable support systems shall be used.
- 5.1.11 Unarmoured cables shall only be used where there is no risk of mechanical damage.
- 5.1.12 Fire resistant cables shall only be supported by fire resistant cable support systems.
- 5.1.13 After cable installation, the open end of all cable sleeves and the openings in building structures specifically provided for the passage of cables (including unused openings) shall be fire sealed to SANS 10177 Part 2, thus preventing the ingress of harmful or flammable gases, liquid, smoke, fire and vermin.

5.2 Separation of Cables

- 5.2.1 Cables shall be classified as follows:

Table 2 Cable Classification

	AC	DC
High Voltage	> 1000 Vrms	> 1500 V
Low voltage (power, control, small power and lighting)	50–1000 Vrms	120–1500 V
Extra-low voltage (signal/instrument, data transmission and telecommunication)	< 50 Vrms	< 120 V

- 5.2.2 Except for reasons of electromagnetic compatibility, where larger separation will be required, the minimum separation distance between cables of different classifications shall be according to the following table.

Table 3 Separation distance

Separation (mm)	Extra Low Voltage	Low Voltage	Other Services (Above Ground)	Other Services (Below Ground)
Extra Low Voltage	-	As specified	150	500
Low Voltage	As specified	2 x cables above ground 100mm below ground	150	500
High Voltage Cables	500	300	300	500
Other Services (Above Ground)	150	150	-	-
Other Services (Below Ground)	500	500	-	-
Note:				
1. The above figures need not to apply to the short lengths of cables near the equipment to which the cable are connected.				
2. Clearances to power lines are excluded from above table as they are covered by the Electrical Machinery Regulations. Furthermore, clearances to traction lines are subject to the regulations of the relevant railway authorities.				

- 5.2.3 The figures specified in the table above do not apply to cables that are installed in separate metal enclosures and/or cables on cable support systems (cable trays/ladders) that are separated with conductive partitions, provided such partitions are electrically bonded to earth.
- 5.2.4 Notwithstanding above, cables of different classifications and/or purpose (e.g. data, audio or power), shall not be installed in the same duct or wireway, and the minimum separation distance shall be kept even when their ducts or wireways are bonded (since radio frequency interference may then still be exhibited).
- 5.2.5 When cables have to cross, the crossing shall be at right angles.

5.3 Cable Trenches in Ground

5.3.1 General

- The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.
- The site shall be preserved as far as possible. Only the minimum of trees, shrubs, rocks, etc. shall be removed and cleared for the cable route.

- c) Where surplus material has to be disposed of, the Contractor shall remove it from site and dispose of it in a location of his choosing in accordance with statutory environmental regulations.

5.3.2 Excavation

- a) The cable trench shall be excavated along the routes indicated on the relevant drawings.
- b) Should the Contractor, during the excavation operations, come across obstacles (or other interferences, e.g. soil drenched with hydrocarbon-based solvents such as spilt oil, which could adversely affect cable insulation), the Contractor shall report the matter to the Engineer, who shall then advise an appropriate course of action.
- c) Trenches shall be dug to within the dimensional tolerances given by SANS 1200, parts DB and LC.
- d) Where the Contractor cannot excavate by means of machines, due to limited access and the proximity of other services, excavations shall be by hand.
- e) The bottom of the trench shall be level and shall follow the contours of the final ground level. Where the excavation is in excess of the required depth, the excavation shall be backfilled and compacted with suitable material to the required depth.
- f) The Contractor shall trim the trenches and clean up the bottom of the trenches after he has completed the required excavation.
- g) The Contractor shall remove all sharp projections, which could damage the cable where the trench is excavated through rocky formations, and shall remove all loose rocks, material, etc. from the bottom of the trench.
- h) No excavated material shall be left closer than 300 mm from the side of the excavation.
- i) Once the excavations for cable trenches have been completed, the Contractor shall give the Engineer one working day notice to inspect the trench and to be present when the measurements are made.
- j) The Contractor shall maintain the excavation in a good condition, free of water, mud, loose ground, rocks, stones, gravel and other strange material until the cables are installed.

5.3.3 Installation of Cables Directly in Ground

- a) Dimensions of trenches for the installation of cables directly in ground
- b) Trenches shall be excavated as follows:

Table 4 Excavation of trenches

	Width	Depth
Telecommunication Cable	450 mm	650 mm
LV Cable	450 mm	650 mm

- c) However, the following minimum clearances shall be maintained:

Table 5 Minimum clearances

	Vertical	Horizontal
Data and Telecom Cables	300 mm	300 mm
Water pipes	300 mm	300 mm
Sewer pipes	300 mm	800 mm
Storm water pipes	300 mm	600 mm
LV cables on same route	100 mm	One cable diameter of larger cable

- d) Where a cable will cross over other services, the cable shall not be installed at a depth less than 600 mm below ground level, and if this is not possible the cable shall be installed underneath the other service and shall be protected in the prescribed manner by means of concrete slabs. The depth of the cable shall be maintained for one metre on either side of the crossing.
- e) If it is not possible to cross over or underneath a service in the prescribed manner, the matter shall be referred to the Engineer for a decision.
- f) Where more than one cable need to be installed in a trench, the width of the trench shall be increased with a distance equal to the clearance required.

5.3.4 Sand bed and sand bed cover for cables

- a) A sand bed layer of soft soil shall be installed and levelled at the bottom of each trench after the trench has been approved by the Engineer, and prior to cable laying.
- b) If the excavated material is not suitable for the sand bed layer, then suitable soil shall be imported for this purpose. Quarried sand, man-made sand, sand clay and loam is usually suitable; sea sand, river sand, clay, chalk, unmixed oukclip, peat and mine sand may not be used. The cost of importing shall be included in the price for the excavation.
- c) The minimum thickness of the sand bed layer shall be 50 mm.
- d) If the soil for the sand bed and sand cover has to be sifted, a sieve with holes not larger than 6 mm shall be used.
- e) The cable shall, after the completion of the trench, be laid as soon as possible so that the trench can be backfilled.
- f) The sand bed cover for LV cables shall be 150 mm thick, of similar soil and shall be placed directly after the cable(s) has been inspected by the Engineer.
- g) Only one cable shall be laid at a time and the Contractor shall take precautions that the cables which are already installed are not damaged.

5.3.5 Laying of cables

- a) Cable rollers shall be used when cables are drawn into trenches. The cable rollers shall be placed so that the cable does not touch the bottom or the sides of the trench.
- b) If the Contractor intends using a winch to draw the cable into the trench, a cable stocking shall be used or the draw wires shall be soldered to the cable, such that the tension is exerted on all the cores, lead sheath and/or steel wire armouring at the same time.
- c) The maximum tension on a cable during laying operations shall not exceed the value specified by the manufacturer.
- d) Sufficient lengths of cable shall be left at the beginning and end of the cable routes to allow for the termination of the cables. The Contractor shall take the necessary precautions to protect the cable ends until they are terminated. The cable ends shall be sealed by means of lead or heatshrink sealing caps to ensure that the cable is waterproof.
- e) Where cables are drawn through sleeves, care shall be taken that they are not kinked or excessively bent.
- f) The Contractor shall keep accurate records of each length of cable laid. The following information shall be recorded:
 - i) Cable drum number
 - ii) Size of cable

- iii) Where the cable has been laid, i.e. the starting and finishing points
- iv) Length of cable
- v) Date laid
- g) The Contractor shall be liable for the repair of cables due to the faulty manufacture, should this information not be recorded directly after the cable has been laid.
- h) The Engineer shall inspect all cable trenches before backfilling to ensure that the laying of cables complies with the specification.

5.3.6 Backfilling of trenches

- a) When the cable has been laid, inspected and approved and the sand bed cover has been installed, the trench shall be backfilled with soil containing not more than 40 % rock or shale which shall be able to pass through a 100 mm sieve and which is approved by the Engineer.
- b) Where more than 40 %, but less than 70 %, rock occurs, the Contractor shall replace the rock with imported soil. However, should more than 70% rock occur then all the backfilling material shall be imported.
- c) The Contractor may import further stone-free material to the site or sieve the excavated material for sand bedding and cover but payment shall only be compensated for the actual quantity of imported material required as determined by the Engineer. The quantity of imported material required shall be calculated from the nominal trench width.
- d) The excavated material shall be backfilled in layers of 150 mm and shall be well compacted and consolidated to 90 % MOD AASHTO. Where the Engineer deems necessary, the Contractor shall use a mechanical vibrator to compact the trench.
- e) The Contractor shall maintain the completed sections of the cable trench in a proper safe condition for the duration of the contract. The Contractor shall refill and compact the trench where subsidence occurs.
- f) After completion of the work the route of the cable shall be neatly finished off and cleared. All stones bigger than 25 mm, as well as all loose organic material and rubble, shall be removed.
- g) Electrical warning tape, consisting of two tapes laid side-by-side and overlapping (such that their combined width is 150 % of a single tape width), shall be installed on all cable routes (LV and MV), 200 mm above the top cable layer. Where a cable route exceeds 600 mm in width, multiple warning tapes shall be run, in such a way that the space between adjacent warning tapes does not exceed 150 mm.

5.3.7 Installation of concrete slabs

Where cables cross other services such as water pipes, sewage pipes and other cables, or where the chance exists that the cable may be damaged as a result of excavation by others, the cable shall be protected by means of reinforced concrete slabs. The slabs shall protect the cable for a distance of 500 mm on either side of the crossing.

5.4 Cable Sleeves

5.4.1 General

- a) The construction of sleeves, draw pits and associated earthworks shall be in accordance with SANS 2001-DP3.
- b) Sleeves shall be PVC unless otherwise specified.

- c) The sleeves shall have a minimum wall thickness of 5 mm and mass not exceeding 45 kg per sleeve length.
- d) Where a change of direction is required, draw pits shall be constructed. Bends may only be used where prior approval has been granted by the Engineer. Where such approval has been granted, the maximum angle of a single bend in a sleeve shall be:
 - i) 45°, when all cables have a diameter less than 35 mm; or
 - ii) 22.5°, where any cable has a diameter greater than 35 mm.
- e) All bends shall be of the long radius type.

5.4.2 Method of Laying

- a) In order to facilitate future location of the sleeves, they are to be installed strictly in accordance with the relevant drawings.
- b) The Contractor shall select the number and/or dimensions of sleeves such that an additional cable, of outside diameter equal to 20 % of the sum of the outside diameters of the installed cables, can be pulled into the sleeve at a future date. Under roadways, this spare capacity shall be 50 %. Notwithstanding above requirement, a minimum of two sleeves shall be installed under all roadway crossings.
- c) When installed beneath roads, there shall be a minimum of 750 mm of cover above the crown of the sleeve, and the sleeve shall be extended to 1,5 m on either side of the road surface or kerb face.
- d) Where sleeves are installed during road construction, the sleeve positions shall be marked with the letters "E" or "ESC" for electrical, and "TEL" for telecommunication sleeves, cut or cast into the concrete of the kerb (or concrete marker, should the road be without kerbs). The grooved letters shall also be painted red, to facilitate easy identification.
- e) The sleeves shall be laid straight to within the dimensional tolerances given by SANS 1200 part LC.
- f) After installation, all foreign matter in the pipe shall be cleared.
- g) The sleeves shall be sealed with PVC plugs to prevent the entry of sand before backfilling.
- h) Precautions shall be taken to prevent damage to the sleeves during future construction activities.
- i) All sleeves shall be left with an 8 mm diameter nylon draw wire, or draw wire to SANS 2001-DP3, in place, anchored at each end.

5.4.3 Bore and Sleeve Jointing

- a) The bore shall be accurate, smooth and without surface cracks, and the inside edges edged or rounded.
- b) The edging or rounding shall be such that no ridge is formed when two sleeves are joined.
- c) A suitable slip collar, or other simple device, shall be provided to maintain the 5 mm spacing after the installation of the sleeves.
- d) Joints shall be carried out with suitable couplings to prevent movement between pipe ends.
- e) Joints shall be flexible enough to allow angular adjustments of up to 5° between adjacent lengths of sleeves during installation and afterwards to allow for subsequent subsidence of the ground.

- 
- f) The joints need not be watertight, but shall stop sand and other materials entering the sleeves.

5.4.4 Draw pits and masonry

- a) Where they are to be constructed in residential or commercial zoned areas, and where part of the draw pit will be visible above ground, the masonry units to draw pits shall be FBS (face brick standard). All other draw pit builds shall utilize solid concrete units.
- b) Draw pits covers shall be of cast iron manufacture, or as specified in the particular specification.



6. MARKING AND LABELLING OF CABLES

6.1 Low Voltage Cables

- 6.1.1 Conductors and/or cables shall be identified at both ends by cable markers, consisting of plastic sleeves with pre-printed, legible and indelible alpha/numeric element inserts. The plastic sleeves shall fully encircle the conductor and/or cable. The markers shall be suitable for the intended environment, for instance, UV resistant where installed in sunlight, etc. Reference character sizes shall not be less than 3 mm high.
- 6.1.2 The colours of conductor PVC insulation shall comply with SANS 10142-1, par. 6.3.3. The colours of conductors for sub-circuits shall as far as possible correspond with the colour of the supply phase. Except in the case of multi-way switching, the colour of a conductor may not change at any point along its run, starting from its point of origin at a circuit breaker inside the switchgear assembly. In other words, where loop wiring is employed, the colour of conductor insulation shall be the same throughout the circuit.

7. DRAWINGS AND DOCUMENTATION

7.1 General

7.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

- a) The Client's name and contact details
- b) Client's project / scheme / contract reference title and numbers
- c) The Engineer's name and contact details
- d) Engineers reference numbers
- e) Contractor's work / contract / order references

7.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

7.2 Drawings for Approval

7.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

- a) Cable route layout drawings showing
- b) Type of wireways
- c) Trenching
- d) Cable junction boxes

7.3 As-built Drawings

7.3.1 The Contractor shall produce detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size. Where the original drawings were larger than A3, 3 sets of printed drawings scaled to A3 size will be supplied. The A3 drawings will not have any information omitted from the printed area. The drawings will indicate the positions of the following:

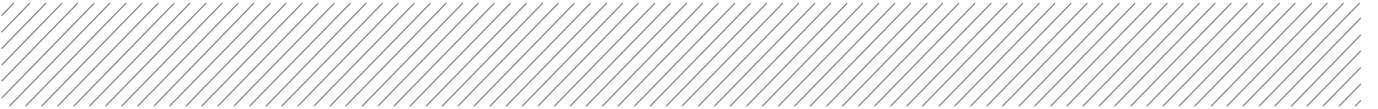
- a) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.);
- b) Cable routes (including any cable joints)
- c) General arrangement drawings
- d) Single Line Diagrams

7.4 Operating and Maintenance Manual

7.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

7.4.2 The operating and maintenance manuals shall include at least the following:

- a) A schedule of installed components and equipment, containing the following information:
 - i) Manufacturers name and contact details
 - ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

- 
- iii) Function (e.g. switching lighting circuit DB03-L1)
 - b) A schedule of all installed cables, with the following information:
 - i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)
 - ii) Size
 - iii) Installed length; and
 - iv) Function (e.g. "Feeding Submersible pump IW-SP-01")
 - c) Description and details of:
 - i) Detailed description of the function of all operator controls
 - ii) Procedures for fault finding
 - iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures
 - iv) Inspection schedules; and
 - v) Spare parts information and recommended spares

8. TESTING AND COMMISSIONING

8.1 General

- 8.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.
- 8.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.
- 8.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and have an up-to-date test and calibration certificate.
- 8.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.
- 8.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.
- 8.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.
- 8.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.
- 8.1.8 If there is a requirement for additional inspection and test activities to be performed as part of the commissioning process, this shall be specified in the Particular Specification.
- 8.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

8.2 Test Sequence

8.2.1 Inspections before testing:

Before testing, inspections shall be performed to verify:

- a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards
- b) All parts of the installation are correctly selected and erected
- c) No part of the installation is visibly damaged or otherwise defective
- d) The installation is suitable for the environmental conditions; and
- e) The installation complies with this Specification

8.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 8.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:



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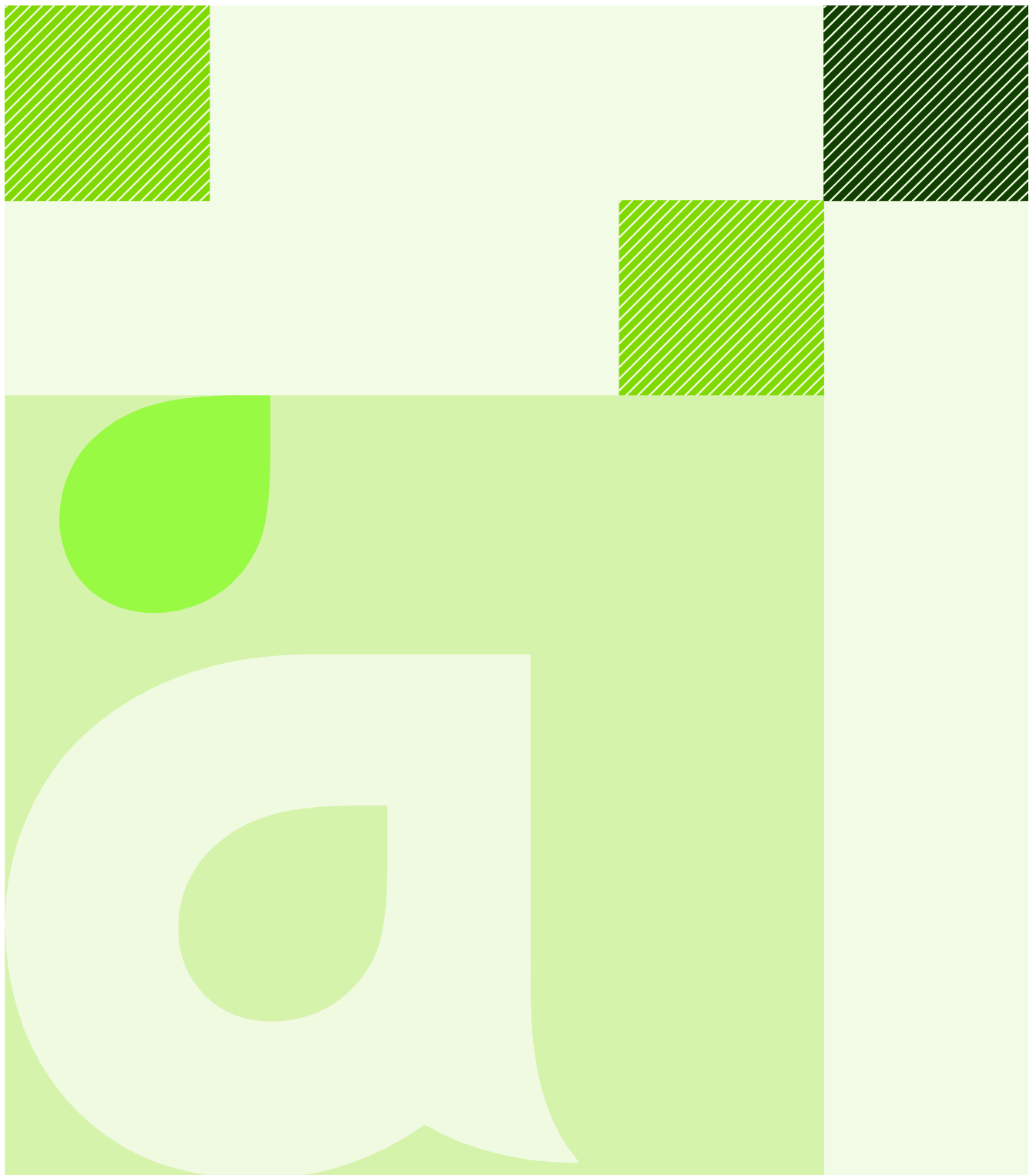
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Low Voltage Electric Motors

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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the performance, design, construction, installation, testing and commissioning of ac three phase, low voltage, squirrel cage, induction motors.

2. STANDARDS

2.1 Associated Documentation and Quality Assurance

- 2.1.1 This Specification sets out the Employer's specific requirements and amendments, which shall be applied to the statutory and referenced standards. The project-specific requirements are contained in the Project Specification, which shall be read in conjunction with this Specification.
- 2.1.2 The design, construction, installation, inspection, testing and commissioning of the Installation shall comply with all relevant Statutory Regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.
- 2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection, testing and commissioning of the installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the Installation shall comply with all relevant Statutory Regulations and Directives including:
- a) Occupational Health and Safety Act (Act 85 of 1993);
 - b) The law of the Republic of South Africa;
 - c) Regulations of the Local Supply Authority.

2.3 Recognised Standards

- 2.3.1 The latest edition, including all amendments up to date of tender of the following particular national and international specification, publications and codes of practice shall be read in conjunction with this specification:

Table 1: Reference Standards

Standard Number	Description
SANS 1804	Induction motors
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 60034	Rotating Electrical Machines
SANS 60072	Dimensions and output series for rotating electrical machines
SANS 60079-0	Explosive atmospheres: Electrical Equipment general requirements

3. GENERAL REQUIREMENTS

3.1 General

- 3.1.1 The motor frame number shall be in accordance with SANS 60072.
- 3.1.2 A dimensioned general arrangement drawing of the motor shall be provided with the Tender.

3.2 Preference for Standardization

- 3.2.1 Electric motors shall comply with the requirements of SANS 60034 and SANS 60072 in accordance with SANS 1804-1.
- 3.2.2 All motors shall be standard catalogue models and shall be readily available.
- 3.2.3 All motors shall, where possible, be from the same manufacturer and motors of the same rating shall be interchangeable. Variations in type and size shall, where possible, be limited to prevent stocking a variety of special spares.

3.3 Electrical Supply Characteristics

- 3.3.1 Unless otherwise specified in the Project Specification, motors which are directly connected to the supply shall be suitable for operating on a 400 V, three phase, directly-earthed, 50 Hz supply.
- 3.3.2 The motors shall be capable of operating continuously with Zone A combined voltage and frequency variations, and infrequently/for limited time with Zone B and C variations, as defined in SANS 60034-1 and SANS 1804-2 without risk of damage. The motors shall deliver rated torque and temperature rise shall not exceed the specified limit for the insulation when operating in Zones B and C.
- 3.3.3 The supply harmonic voltage factor shall be as stated in SANS 60034-1, but the supply voltage negative-sequence component shall be 2 %.
- 3.3.4 The direction of rotation shall be clockwise (viewed from the drive end) when the motor is connected to a three phase supply of Red/White/Blue anti-clockwise phase rotation unless otherwise specified in the Project Specification, with the Red/White/Blue phases connected to the UVW terminals respectively.
- 3.3.5 As required by SANS 60034-1, the motor manufacturer shall declare a limiting value for the peak voltage and for the voltage gradient in continuous operation for converter-fed motors, and these limits shall be provided with the Tender.

3.4 Motor type and rating

- 3.4.1 Motors shall be of the squirrel-cage induction motor type. Slip-ring induction motors or other approved types may be offered as alternatives for consideration by the Engineer if the Contractor is of the opinion that better results could be obtained by using such motors.
- 3.4.2 Full electrical and mechanical details of each alternative shall be submitted with the Tender.
- 3.4.3 Motors shall be adequately rated for the service for which they are intended, and due allowance shall be made for the site operating conditions specified in the Project Specification.

- 3.4.4 Unless otherwise specified in the Project Specification, the motors shall have a synchronous speed of 1500 rpm at 50 Hz and the operating speed range shall be as required by the driven equipment.

3.5 Weights and Lifting Arrangements

- 3.5.1 The weight of the complete motor shall be stated in the Tender submission.
- 3.5.2 If the motor weighs over 5 kg, it shall be fitted with eye-bolts, lugs or extension pieces for lifting the motor. Eye-bolts shall be of the shouldered pattern and shall be properly fitted to pull down securely onto the shoulder.
- 3.5.3 If specified in the Project Specification, motors shall be fitted with jacking bolts or equivalent facilities to lift and position the motor for lining up.

3.6 Mounting Arrangements and Drive

- 3.6.1 The type of construction and mounting arrangement shall be as specified in the Project Specification.
- 3.6.2 Motor mounting references shall be in accordance with SANS 60034-7.
- 3.6.3 The drive method (i.e. direct/belt/gearbox) shall be as specified in the Project Specification.
- 3.6.4 Submersible pumps and their integral motors shall be suitable for vertical mounting in both a wet- and dry well.

3.7 Mechanical Construction

- 3.7.1 The motor frame may be manufactured from aluminium only for motors up to 22 kW.
- 3.7.2 End shields for all motors over 22 kW shall be manufactured from cast iron, regardless of whether the motors have steel or cast iron frames.
- 3.7.3 Shafts shall comply with the requirements of SANS 1804-2.
- 3.7.4 For submersible motor the motor shaft shall be manufactured from 316 stainless steel and shall be provided with double shaft sealing by means of mechanical seals which are independent of direction of rotation. Seal monitors shall be provided to detect leakage through the seals.

3.8 Rating Plate

- 3.8.1 The rating plate shall be made of a corrosion resistant metal and shall be indelibly stamped or engraved with the information specified in the relevant part of SANS 60034-1.
- 3.8.2 The information contained on the rating plate shall be clearly accessible and visible after the motor has been painted.

3.9 Motor/Load Coupling Method

- 3.9.1 Motors shall be coupled directly to the driven load unless otherwise specified in the Project Specification.
- 3.9.2 Motors for belt-driven loads shall be supplied with slide rails complete with motor fixing screws.

- 
- 3.9.3 Coupling, pulley and slide rails fitting and alignment shall be carried out in accordance with good engineering practice.

3.10 Earthing

- 3.10.1 All motors shall be provided with an earthing terminal which is located inside the main terminal box in accordance with SANS 60034-1.
- 3.10.2 An additional earthing terminal shall be fitted on the motor frame external to the terminal box.

4. ENVIRONMENT AND ENCLOSURES

4.1 Enclosure and Frame

- 4.1.1 Each motor shall be protected to the degree required by its application, and its enclosure shall be designed for the system of cooling associated therewith.
- 4.1.2 Notwithstanding the requirements above, the minimum degree of protection shall be IP55 to SANS 60034-5 unless otherwise specified in the Project Specification.
- 4.1.3 All motors of the vertical-spindle type and exposed to the weather, shall be provided with a robust canopy of approved design.
- 4.1.4 Medium-length motors are preferred but short-length motors may be accepted where space is limited and written permission has been granted by the Engineer.
- 4.1.5 The submersible pump motors shall have an ingress protection rating of IP 68 i.e. suitable for continuous immersion at the required installation depth.

4.2 Operating Environment

- 4.2.1 The operating environment of the motor will be as specified in the Project Specification.
- 4.2.2 Unless the operating environment specified in the Project Specification is more severe, the motor shall be capable of satisfactory operation under the operating conditions specified in SANS 60034-1.
- 4.2.3 Any special hazards associated with the operating environment (e.g. high levels of sand/dust, chemical pollution and/or shock/imposed vibration) will be specified in the Project Specification and due allowance shall be made for these hazards.

4.3 Materials Selection

- 4.3.1 Materials shall be selected with proper reference to the specified operating environment and asset life.

4.4 External Corrosion Protection

- 4.4.1 If specified in the Project Specification, the motor shall be provided with corrosion protection for a highly-corrosive environment. Details of the paint finish shall be provided with the Tender.

4.5 Thermal Protection

- 4.5.1 Unless otherwise specified in the Project Specification, if the motor is rated at 55 kW or above, it shall be fitted with built-in thermal protection as specified below.
- 4.5.2 Motors smaller than 150 kW shall be fitted with positive temperature coefficient (PTC) thermistors suitable for Class B temperature rise protection. Two thermistors shall be located in close thermal contact with each phase of the stator windings and all thermistors shall be connected together to provide a single electrical circuit for external connection.
- 4.5.3 Motors rated 150 kW and above shall be equipped with two resistance temperature detectors (RTDs) of the PT100 type per winding and one per bearing. The RTDs shall be of the three-wire type with stainless steel sheath and mineral insulation.

- 
- 4.5.4 The bearing RTDs shall be spring-loaded and be in contact with the outer bearing race. They shall be of the screw type with weatherproof die-cast alloy heads and shall be fitted with 2-wire 4-20 mA transmitters unless otherwise specified.
 - 4.5.5 The wires of all detectors shall be wired to a terminal strip in a dedicated terminal box on the motor.
 - 4.5.6 For submersible pumps above 150 kW the pump bearings shall also be fitted with RTDs of the PT100 type.

4.6 Cooling

- 4.6.1 If the motor is to be vertically mounted with a shaft-down configuration, it shall be fitted with a drip-proof, top-end cowl.
- 4.6.2 Unless otherwise specified on the Project Specification, the method of cooling shall comprise shaft-mounted fans with frame surface cooling i.e. method IC 411 in accordance with SANS 60034-6. However, the Tenderer shall determine if separately-powered fans are required with variable speed drives i.e. cooling method IC 416 or IC456.
- 4.6.3 Submersible pump motors shall have a closed-loop integrated cooling system to allow for both wet- and dry well installation.

5. PERFORMANCE

5.1 Duty and Rating

- 5.1.1 Motors shall be rated for continuous running duty type S1 unless otherwise specified in the Project Specification or if a more onerous duty is dictated by the driven load.
- 5.1.2 Motors shall have a continuous rated output not less than 15 % in excess of the maximum load absorbed power over the operating range, unless otherwise specified in the Project Specification.

5.2 Efficiency and Power Factor

- 5.2.1 The tendered efficiency and power factor of all motors shall be guaranteed by the Contractor. Deviations from the guaranteed values shall be within the tolerances specified in SANS 60034-1.
- 5.2.2 Unless otherwise specified in the Project Specification, motors shall be of the High Efficiency type (class IE2) to SANS 60034-30.

5.3 Starting

- 5.3.1 The method of starting shall be as specified in the Project Specification.
- 5.3.2 Motors shall be capable of six starts per hour, with two being consecutive starts from normal operating temperature, unless otherwise specified in the Project Specification.
- 5.3.3 All squirrel-cage induction motors shall be suitable for direct-on-line starting at full voltage. Single-speed motors shall conform to SANS 60034-12, Design N or NY characteristics for DOL and star/delta starting respectively, unless otherwise specified in the Project Specification or dictated by the driven load.
- 5.3.4 Motors shall develop adequate torque to accelerate the driven equipment to full speed, within an acceptable time, using the starting method specified in the Project Specification. For direct-on-line (DOL) starting the motor terminal voltage shall be taken to be 85 % of the rated voltage. For other starting methods the motor terminal voltage shall be taken to be the output voltage of the reduced-voltage starter.
- 5.3.5 The maximum allowable line starting current shall be as specified in the Project Specification.

5.4 Noise Level

- 5.4.1 Motors shall be of 'normal sound power' type unless the specification calls for low noise motors and/or the fitting of sound attenuators.
- 5.4.2 The sound power levels of motors measured during type tests shall not exceed the values specified in SANS 60034-9.

5.5 Vibration

- 5.5.1 Motors shall be statically and dynamically balanced.
- 5.5.2 All motors shall be subjected to vibration measurements without load, and at full rated voltage at the manufacturer's works, in accordance with SANS 60034-14.

- 
- 5.5.3 The maximum level of vibration shall meet the Grade A limits in SANS 60034-14 unless otherwise specified.

5.6 Temperature Rise

- 5.6.1 Motors shall have a Class B temperature rise based on the operating conditions stated in SANS 60034-1, but with appropriate adjustments should the actual operating conditions be more severe (i.e. higher ambient temperature or altitude exceeding 1000 m).

6. MOTOR TERMINAL BOX

6.1 Terminal Arrangements

- 6.1.1 The line connections of each motor shall be brought out to a terminal box located in an approved position. In the case of two-speed motors, separate terminal boxes shall be provided for the separate windings.
- 6.1.2 Terminals shall be designed for bolted terminations with cable lugs and shall be sized to accept the cables stated in the Project Specification.
- 6.1.3 The electrical clearance and creepage distances shall be in accordance with SANS 1804-2.
- 6.1.4 Motors suited for only one-directional rotation, shall be clearly marked as such by an arrow on the motor frame at the driving end.
- 6.1.5 Terminal markings shall be in accordance with SANS 60034-8 and a diagram plate shall be permanently attached inside the terminal box cover showing the connections for the specified direction of rotation.

6.2 Terminal Boxes

- 6.2.1 Terminal boxes shall be IP55 rated and shall be adequately sized for the cables and cable entry specified in the Project Specification.
- 6.2.2 Terminal boxes shall be certified to withstand both a through-fault and a short-circuit in the terminal box, based on the maximum fault level at the point of connection.
- 6.2.3 The terminal box shall be of the same material as the motor frame up to frame size 160 (i.e. aluminium/steel/cast iron), but larger motors shall have cast iron boxes. The position of the terminal box (viewed from the drive-end if the motor is foot mounted) shall be as specified in the Project Specification.
- 6.2.4 The terminal box shall have an internal earth terminal in accordance with SANS 60034-1.
- 6.2.5 For motors rated at 30 kW or above, the terminal box shall be fitted with a detachable metal gland plate or cable box to suit mechanical compression cable glands for terminating 4-core PVC/SWA/PVC or XLPE/SWA/PVC cables. Where single core cables are specified, the gland plate shall be of a non-magnetic material. All terminal boxes shall be fitted with removal covers.
- 6.2.6 Submersible pump motors shall have a sealed cable connection chamber with the connection made to protect the cable against excessive tension and bending. A moisture sensor shall be provided in the terminal box to detect water ingress.
- 6.2.7 The motor shall be fitted with an integral neoprene cable with adequate length.

7. BEARINGS

7.1 Bearing types and requirements

- 7.1.1 Bearings shall be of the rolling- or sliding-element type as appropriate to the application, and shall be mounted integral to the motor.
- 7.1.2 Bearings shall have a minimum L10 life rating of 100 000 hours for horizontal direct drives, 40 000 hours for horizontal belt drives, and 10 000 hours for vertical motors at the rated load and speed for the application in accordance with ISO 281.
- 7.1.3 Submersible pump bearings shall have an L10 life rating of 100 000 hours and shall be lubricated and sealed for life i.e. they shall be maintenance-free.
- 7.1.4 Rolling-element bearings shall preferably be grease-lubricated unless the application necessitates oil-lubrication.
- 7.1.5 Grease-lubricated bearings may be sealed-for-life type on smaller motors (typically up to frame size 112), but regreasable bearings shall be provided on larger motors.
- 7.1.6 Regreasable bearings shall be conservatively loaded to provide a greasing interval of at least 4 000 hours. Grease nipples, fitted with extension tubes where access is restricted, shall be provided to allow regreasing while the motor is in operation.
- 7.1.7 Regreasable bearings shall have grease relief valves to ensure that the bearings are not over-greased. The relief valves shall be positioned so that the excess grease can be easily removed. Cups shall be fitted to contain excess grease.
- 7.1.8 Bearings which are oil-lubricated shall be provided with a readily accessible filler and a clearly visible oil level indicator. For large motors forced-lubrication may be offered as an alternative.
- 7.1.9 Sliding-element (sleeve) bearings shall preferably be of the plain journal type and shall be automatically lubricated by oil rings or discs integrally-mounted on the shaft, running in an oil bath. The oil bath shall be fitted with filler and drain plugs, and a level indicator. If forced-lubrication is offered, full details of the proposed system shall be provided with the Tender.
- 7.1.10 Bearing seals shall be selected to suit the lubrication method and the operating environment. Internal bearing clearances and the type/grade of lubricant shall be suited to the ambient temperature where lower/higher than normal.



8. HEATERS

8.1 Anti-condensation heaters

- 8.1.1 Unless otherwise specified in the Project Specification, motors shall be supplied with anti-condensation heaters to raise the temperature inside the motor several degrees above the dew point temperature when the motor is not operational to prevent moisture from condensing in the motor. The heaters shall be either self-regulating or thermostatically-controlled.
- 8.1.2 Heater terminal boxes shall be fitted on the motor frame and shall be of robust design, liberally sized and complete with suitable terminal block and mechanical cable gland or conduit entry.
- 8.1.3 Unless otherwise specified , anti-condensation heaters shall be arranged to operate from a separate 230 V, single phase supply from the associated motor starter and shall be terminated in an enclosure clearly marked 'DANGER SEPARATE HEATER SUPPLY - ISOLATE BEFORE REMOVING COVER'.



9. HAZARDOUS AREAS

9.1 Hazardous Area Application

If the motor is to be used in a hazardous area, the additional requirements of this section shall apply.

9.1.1 Design Requirements

- a) The type of hazard, zone classification and gas/dust group (if applicable) shall be as specified in the Project Specification.
- b) The type of motor protection and temperature classification shall be appropriate for the application and shall be selected in accordance with SANS 10108 The Classification of Hazardous Locations and the Selection of Apparatus for Use in Such Locations.
- c) The motor construction, testing and marking shall comply with SANS 60079-0 Explosive atmospheres: Equipment – General requirements.

9.1.2 Testing and Certification

Hazardous area application test certificates shall be provided with the Tender.

10. VARIABLE SPEED DRIVES

10.1 Variable Speed Drive Applications

10.1.1 General

If a motor is to be used with a variable frequency converter (VFC) to function as a variable speed drive (VSD), the additional requirements of this section shall apply and the motor shall comply with SANS 60034-25: Guidance for the design and performance of ac motors specifically designed for converter supply.

10.1.2 Duty and Rating

The motor shall be selected to operate satisfactorily with the VFC over the operating range of the driven equipment. The motor rating shall be determined in consultation with the VFC manufacturer.

10.1.3 Vibration

Where additional vibration is caused by the harmonic content of the VFC voltage output wave form, the overall vibration level shall be within the permissible limits for a fixed speed motor of the same rating (refer Clause 5.5).

10.1.4 Cooling

If required by the duty, the cooling fan for the secondary coolant shall be mounted independent of the motor shaft and powered by its own motor (cooling method IC416). A separately-powered fan shall similarly be provided for the primary coolant if required (cooling method IC456).

10.1.5 Insulation

To ensure that no service lifetime reduction of the motor insulation occurs, the motor shall be selected so that the voltage stress level (at the motor terminals) does not exceed the motor insulation system voltage stress withstand capability.

10.1.6 Terminal Boxes

The terminal box shall incorporate any particular requirements detailed by the VFC manufacturer in respect of the termination and earthing of cable conductors and screens for EMC purposes.

10.1.7 Bearings

Measures shall be taken to prevent harmful levels of bearing currents. Should the VFC be equipped with suitable output filters, no further measures are required. Otherwise the motor shall be equipped with an insulated NDE bearing and a shaft earthing brush (larger motors) or with insulated DE and NDE bearings (smaller motors) as considered appropriate by the motor manufacturer.

10.1.8 Torque/speed Curves

Running torque vs speed curves, drawn over the complete operating range, shall be provided for the motor when operated off the VFC.

11. DRAWINGS AND DOCUMENTATION

11.1 General

- 11.1.1 The requirements of this section shall apply unless drawings and documentation are dealt with in the Project Specification.
- 11.1.2 All drawings, information, and documentation shall be in English, and each item shall be identified with the Employer's name and project / scheme / contract reference title and numbers, the Engineer's name and reference numbers, and the Manufacturer's works / contract / order references. Drawings for acceptance shall be provided on A3 paper copies.

11.2 Drawings

- 11.2.1 Detailed "as-built" drawings shall be provided by the Contractor showing the following:
 - a) Motor and terminal box construction details
 - b) Motor performance curves

11.3 Operating and Maintenance Manual

- 11.3.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all motors supplied. The operating and maintenance manuals shall include at least the following (manual's format shall be of A4):
 - a) A schedule of all components equipment in the installations with the following information shall be provided:
 - i) Manufacturers name and contact details
 - ii) Motor tag number
 - iii) Function (e.g. 'Booster Pump')
 - b) Full description and details of design capacity and design criteria for each item of equipment and each product.
 - c) Procedures for fault finding.
 - d) Maintenance instructions for all motors and components and including repair, overhaul, change-out and installation procedures.
 - e) Details of the maintenance tasks and schedules required to achieve the specified motor asset life.
 - f) Spare part information.

11.4 Information to be supplied with Tender

- 11.4.1 Details of the maintenance tasks required and frequency.
- 11.4.2 A dimensioned general arrangement (GA) drawing of the motor and its main terminal box.
- 11.4.3 Details of the paint system provided for use in a highly polluted environment.
- 11.4.4 A set of complete data sheets from the motor manufacturer for every type of motor provided, including starting torque/speed and current/speed curves.

12. INSPECTION AND TESTS

12.1 Factory Tests

- 12.1.1 All motors shall undergo routine testing and all new motor designs shall have been/shall be proven through type testing at the manufacturer's factory.
- 12.1.2 All type tests required by SANS 1804-2 shall be carried out, as well as the following additional tests if called for in the technical Project Specification:
- a) Current/speed curve
 - b) Torque/speed curve
- 12.1.3 All routine tests required by SANS 1804-2 shall be carried out, as well as the following additional tests if called for in the technical Project Specification:
- a) Insulation resistance check
 - b) Vibration velocity measurement
- 12.1.4 Type test certificates shall be provided for all motors that are only subjected to routine tests.

12.2 Commissioning Inspections and Tests

12.2.1 Inspections before testing

Before testing, inspections shall be performed to verify:

- a) All motor earth connections (frame and terminal box) are in place and tightened
- b) Motor coupling guards are in place and securely fixed
- c) Power cables are correctly connected and tightened to correct torque
- d) The motor and its immediate environment are clean

12.2.2 Tests before motor starter is energized

Before the motor starter is energized the following tests shall be performed:

- a) Continuity of earthing conductors
- b) Insulation resistance of windings (before connection of power cables)
- c) Control, protection and alarm circuits and equipment are set and functioning correctly

12.2.3 First start and run checks

On satisfactory completion of the tests specified above, items (a) – (b) shall be checked when a motor is first started, and the other items shall be checked over the first 4-8 hours of running under load:

- a) Direction of motor rotation
- b) Direction of rotation of separately-powered fans (where relevant)
- c) Load current
- d) Winding and bearing temperatures
- e) Vibration
- f) Abnormal noises



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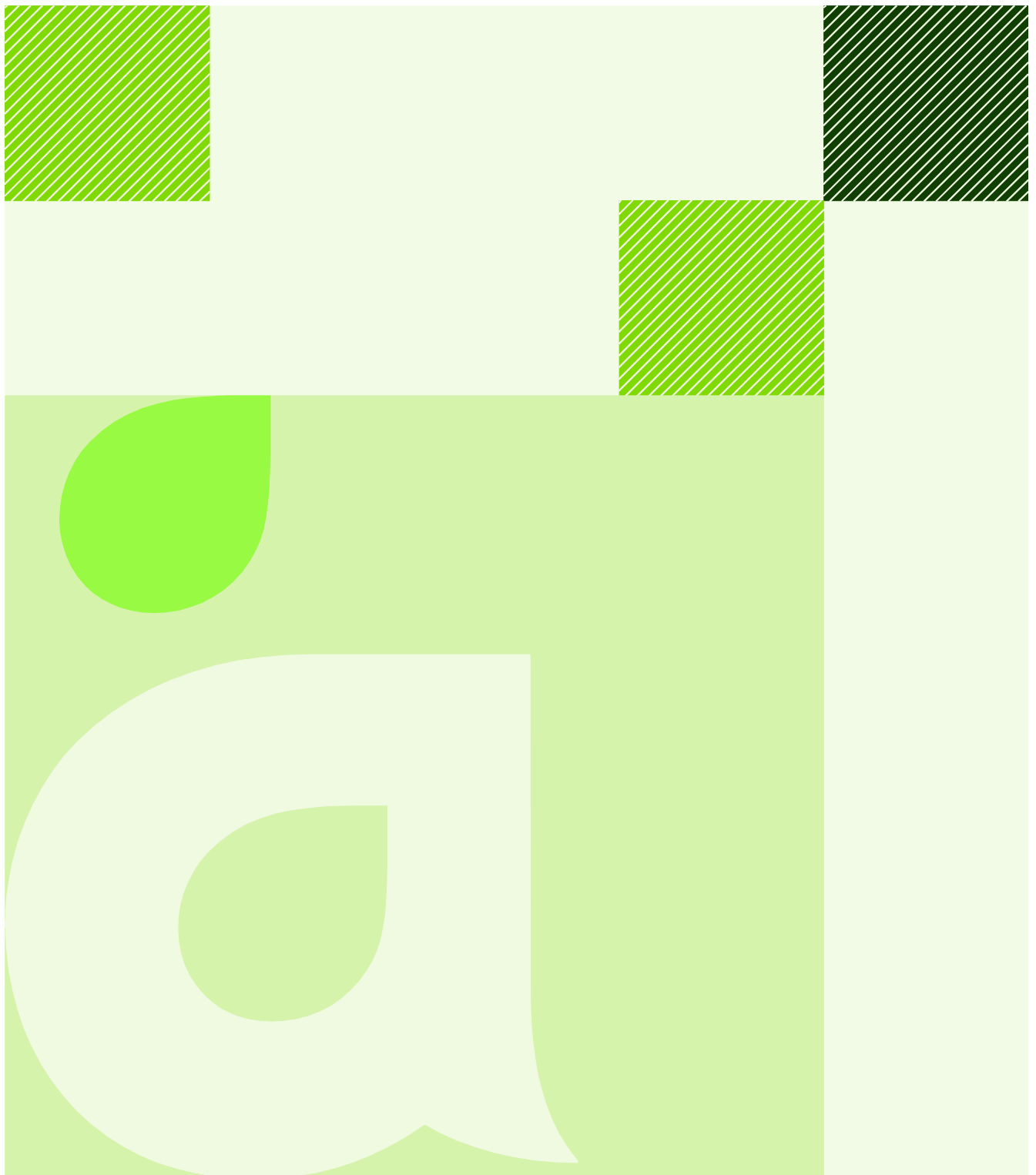
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1. SCOPE

1.1 Application

- 1.1.1 This Standard Specification defines the requirements for the design, construction, installation, inspection, testing and commissioning of LV switchgear and controlgear assemblies (Assemblies), including distribution boards (DBs), motor control centres (MCCs), single standalone motor starters or controllers, control panels (either standalone or forming an integral part of the Assembly), control desks and consoles. Where this type of electrical equipment is incorporated within a plant supply package, the provisions of this Specification shall also apply.

1.2 General Requirements

- 1.2.1 An Assembly shall incorporate all components and equipment necessary to achieve the functionality defined in the Project Specification.
- 1.2.2 All materials, components, and equipment used in the manufacture of the Assembly shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification contains standard amendments and requirements which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.
- 2.1.2 The design, construction, installation, inspection, testing and commissioning of the Assembly shall comply with all relevant statutory regulations, and the latest editions (current at the time of Tender) of all relevant South African National Standards.
- 2.1.3 The manufacturer shall operate an approved, auditable quality assurance system covering the design, construction, inspection and testing of the Assembly.

2.2 Statutory Requirements

- 2.2.1 The Assembly as manufactured, and as installed on site, shall comply with the following:
- a) Occupational Health and Safety Act of 1993
 - b) Manufacturer's specifications and installation instructions

2.3 Reference Standards

- 2.3.1 The Assembly and all its constituent components and equipment shall comply with the latest published edition of all relevant national standards, including the following:

Table 1: Reference Standards

Standard Number	Description
SANS 152	Low-voltage air-break switches, air-break disconnectors, air-break switch-disconnectors, and fuse-combination units
SANS 156	Moulded case circuit-breakers
SANS 172	Low Voltage Fuses
SANS 1091	National colour standards for paint
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 9000	Quality management systems
SANS 10108	The classification of hazardous locations and the selection of apparatus for use in such locations
SANS 10142	Standard Regulations for Wiring of Premises.
SANS 60044	Instrument Transformers
SANS 60204	Safety of machinery. Electrical equipment of machines.
SANS 60269	Low-voltage fuses.
SANS 60439	Low-voltage switchgear and controlgear assemblies
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61558	Isolating transformers and safety isolating transformers.
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems

3. CONSTRUCTION REQUIREMENTS

3.1 General

- 3.1.1 Assemblies shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance.
- 3.1.2 The arrangement of all circuit components / functional units shall be to the approval of the Engineer.
- 3.1.3 Where detailed in the Project Specification, spare compartments of a given size shall be provided within the enclosure. Each shall be equipped with a plain (i.e. un-punched) opening compartment door.
- 3.1.4 Every spare compartment shall be sized to house a triple pole and neutral incoming short circuit protective and isolating device, and shall be provided with a compartment earthing terminal.
- 3.1.5 Every spare compartment shall be provided with a gland plate or have access to an existing cable way within the enclosure.

3.2 Enclosures

- 3.2.1 All conductors and terminals that form part of the Assembly, including earth conductors and the Assembly earth bar, shall be enclosed within it. An earth stud may be provided as a part of a cable glanding facility.
- 3.2.2 Assemblies shall be constructed of materials capable of withstanding the mechanical, electrical and thermal stresses to which it may be subjected and the environmental and operating conditions likely to be encountered in normal service.
- 3.2.3 All boards, panels and cubicles shall be vermin and dust proof and the minimum degree of protection shall be:

Table 2: Minimum levels of ingress protection

Location	Description	Minimum rating
Indoor	Clean, dry areas (e.g. inside substations or motor control rooms)	IP44 (doors closed)
		IP2X (inter-compartment & doors open)
Outdoor	Located outside buildings	IP65 (doors closed)
		IP2X (inter-compartment & doors open)

- 3.2.4 Where heat is generated within the enclosure, it shall, where possible, be designed to dissipate naturally from the enclosure surface. Where this is not possible, ventilation openings shall be provided that maintain the highest practicable IP rating of the enclosure, subject to a minimum of IP42. Where cooling air is drawn into the enclosure, dust filters shall be provided where practicable.
- 3.2.5 For all variable speed drives and soft-starters (without bypass contactors) installed in indoor Assemblies, mini-extraction fans shall be installed inside the drive compartment to dissipate heat, without compromising the assembly's IP rating.
- 3.2.6 Particular attention shall be given to the ventilation of outdoor mounted boards, to eliminate build-up of excessive heat inside the boards caused by the solar radiation or internal heat generation.
- 3.2.7 Any internal partitions necessary to provide inter-compartmental segregation within the enclosure shall be of the same material as the sides of the enclosure.

3.2.8 All the surfaces of the enclosure, and of its constituent equipment and components shall be suitably protected against the effects of any likely atmospheric corrosion present at the operating location.

3.2.9 Purpose-made gland plates shall be protected against corrosion by electro-plating, galvanising, or be made of stainless steel and shall not be painted.

3.3 Construction of Free-Standing MCCs and DBs

3.3.1 Free-standing MCCs and DBs shall be constructed from steel with a structural frame permanently clad with side plates, so as to provide a multi-compartmented structure that is rigid with all doors and covers removed, and such that it will not deform during transport or installation. The enclosure doors and covers shall themselves be suitably braced so as to be rigid and not deform or flex when fully equipped and handled.

3.3.2 Each compartment formed within the enclosure for the purpose of housing components or equipment shall be provided with dedicated mounting plates for that purpose, which when removed do not expose any other compartment or live parts. Cabling shall only be terminated on or in the enclosure at gland plates provided for that purpose.

3.3.3 Horizontal wireways (top and bottom) shall extend through the width of each section.

3.3.4 The minimum metal thickness of the enclosure's constituent parts shall be as follows:

- a) External cladding : 2 mm
- b) Internal partitions: 1,6 mm
- c) doors and removable panel covers: 2 mm

3.3.5 Free-standing Assemblies shall be mounted on and bolted to a rigid hot-dip galvanised steel 100 x 50 x 6 mm channel base.

3.3.6 The maximum height of any Assembly (including its base) shall be 2100 mm above finished floor level. No equipment other than busbars and/or inter panel control wiring shall be installed higher than 1900 mm above finished floor height, neither shall any equipment, other than cable glands and inter panel control wiring be installed lower than 300 mm above finished floor level.

3.3.7 Compartment single doors shall have vertical hinges mounted on their left hand side, and all doors shall have an angle of opening that is limited to 95 degrees. Where specifically agreed with the Engineer, a compartment single door on a front access only Assembly may be hinged on the right hand side if this will reduce the number of dropper / cable way chambers required. Wide compartments with dual doors shall open in wardrobe style, such that the second door is interlocked with the first.

3.3.8 Any cover which is required to be removed for adjustment, access, or maintenance and exceeds 0.75 m² in area, shall be provided with supporting lips, lift-off hinges, locating dowels, or handles, in order to facilitate safe removal and replacement.

3.3.9 Doors and any covers shall be fixed to the enclosure using captive bolt type fasteners, and each hinged door shall be capable of being removed, following disconnection of the electrical and earthing connections. Compartment doors shall be provided with securing catches which can be locked with a padlock, as follows:

- a) door ≤ 400 mm high 1 No.
- b) door > 400 mm high 2 No.
- c) door > 1200 mm high 3 No.

- 
- 3.3.10 The Assembly shall be constructed for front and rear access unless otherwise specified in the Project Specification. Where the Assembly shall be designed for front access only it shall be possible to gain access to every component, item of equipment, busbar and cable from the front (or for busbars, the top) of the enclosure; whether for maintenance or for replacement.
- 3.3.11 The form of internal separation (in accordance with SANS 60439-1) shall be as specified in the Project Specification. Form 3b or 4a as appropriate, shall be considered the minimum allowable internal separation for MDBs and MCCs.
- 3.3.12 Any apertures between compartments (including busbar compartments) through which the copper-work or cabling passes, shall be effectively closed off to minimise the possibility of an arc fault propagating between compartments.
- 3.3.13 Fixings for components, component mounting plates, etc. shall not penetrate another compartment containing live parts. Where self-tapping screws are used for component fixing they shall be of the thread forming or thread rolling type. Components, wiring, labelling, etc., shall only be located within compartments on a removable mounting plate, and in such a manner that facilitates easy inspection, maintenance, or removal and replacement, and without necessitating the removal or dismantling of any other components or wiring, or the use of special tools.
- 3.3.14 Unless detailed otherwise specified in the Project Specification, the Assembly shall be constructed so as to facilitate future extension by the addition of extra full height sections at either end. To accommodate this, any covers, fixings, etc. shall be flush with the end faces of the enclosure, and the end sections of busbars and earth bars shall be prepared for future extension.
- 3.3.15 The Assembly shall be constructed so as to permit it being split into sections in order to facilitate transportation and subsequent site erection. Each transportable section shall be labelled as to its shipping weight, shall be equipped with lifting eyes, which shall be removed on completion of the site erection.
- 3.3.16 All Assemblies shall have at least 15 % spare unequipped space complete with busbars, partitioning into compartments, etc. for future extensions.

3.4 Power distribution within an Assembly

- 3.4.1 The power distribution and circuit protective arrangements within an Assembly shall be designed so as to co-ordinate with the characteristics of the electrical system(s) connected to the incoming terminals of the Assembly, including emergency or temporary supplies and specifically noting the following:
- a) maximum prospective RMS short circuit current from all simultaneously available sources of supply, together with any fault contribution from large motors directly connected to the Assembly
 - b) type of system earthing (i.e. TN-S, TT, etc.), the maximum available earth fault current, and the maximum earth fault loop impedance
 - c) up-stream protective device ratings and settings
- 3.4.2 Where this information is not stated in the Project Specification, it shall be obtained from the Engineer before the design of the Assembly commences.
- 3.4.3 Where the maximum prospective RMS short circuit current from all simultaneously available sources of supply, together with any fault contribution from large directly- connected motors, exceeds 10kA, the Assembly a Type Tested Assembly with stated deviations in compliance with SANS 1973-1.

- 3.4.4 Where the maximum prospective RMS short circuit current is 10kA or less, the Assembly shall comply with the requirements of SANS 1973-3.

3.5 Functional unit short-circuit protection and isolation

- 3.5.1 The Assembly shall be provided with separate incoming isolation for every electrical power system (including emergency or temporary supplies) connected to it.
- 3.5.2 The connection from the Assembly power distribution system into every compartment shall be terminated on a short circuit protection device, which may also incorporate a compartment isolating device, for short-circuit protection of all the components within a functional unit.
- 3.5.3 Every motor starter compartment shall be provided with a door interlocked isolation device, which shall isolate all sources of supply that enter the motor starter compartment. Where a functional unit; e.g. a motor starter, etc., comprises a group of interlocked compartments, the isolation device shall be located in the compartment receiving the supply.
- 3.5.4 Every compartment containing a distribution board or low voltage transformer shall be provided with an isolation device, which may be located in an adjacent compartment. For some compartments housing power monitoring equipment or instrumentation and process control equipment, it may be appropriate to provide a means of isolation within the compartment.
- 3.5.5 Unless separate fuses are used as the short circuit protection device, the isolation device and short circuit protection device shall be combined. Fuses may only be used to limit fault currents if approved by the Engineer.
- 3.5.6 Separate isolating devices shall be switch-disconnectors suitable for on-load switching. They shall be capable of being padlocked in the isolated / 'off' position at the compartment door, and at the isolating mechanism with the compartment door open. Any isolator mechanism extension shafts shall be provided with guide brackets as necessary to prevent excessive shaft deflection.
- 3.5.7 The compartment door shall be mechanically interlocked such that it shall not be possible to open the door when the isolating device is in the 'on' / 'closed' position or when the operating handle is padlocked in the 'off' / 'open' position. Where the means of isolation is only accessible from within the compartment, it shall be protected to a level of IP2X.
- 3.5.8 The following types of devices may be used:
- a) Air circuit breaker (ACB) or moulded case circuit breaker (MCCB)
 - b) Fuse switch-disconnector
 - c) Switch-disconnector with separate fuses
- 3.5.9 All field circuits connected to a functional unit (e.g. valve actuators, limit switches, etc.) shall be provided with isolation either by or within that functional unit.
- 3.5.10 Where safety interlock keys are provided, e.g. to control device operation or to restrict access, they shall only be released in the safe condition, and shall be unique across that Assembly and any other Assembly installed at the same site.

4. ELECTRICAL COMPONENTS

4.1 Circuit Breakers (CBs)

- 4.1.1 Circuit breakers shall be either air circuit breakers (ACBs) or moulded case circuit breakers (MCCBs), as indicated on the single-line diagram for the Assembly.
- 4.1.2 CBs shall have a rated service short-circuit breaking capacity not less than that of the maximum prospective fault current at the point of connection in the power system, which shall be taken to be the busbar rated short-time withstand current specified for the Assembly. Incomer CBs shall have a rated short-time withstand current and time not less than that of the busbars.
- 4.1.3 CBs with rated currents over 100 A shall have built-in protection, that will discriminate with both up-stream and down-stream protective devices, as appropriate to the application.
- 4.1.4 ACBs for incomer and feeder applications shall be fitted with adjustable electronic protection. MCCBs for incomer applications shall be fitted with adjustable thermal-magnetic or adjustable electronic protection.
- 4.1.5 An ACB shall incorporate padlockable cover(s) to permit the securing of the open, close, and trip actuators against inadvertent or unauthorised manual operation.
- 4.1.6 Where an ACB or MCCB has electrically operated control circuits; e.g. opening, closing, tripping, spring charging, indication, etc., they shall be provided with individual fuse or MCB protection.
- 4.1.7 All ACBs and selected MCCBs (as indicated on the single-line diagrams) shall be of a withdrawable pattern with the number of poles indicated on the single-line diagram.
- 4.1.8 A withdrawable ACB or MCCB shall be provided with clearly visible carriage position indication (connected/disconnected/test), and shall be capable of being locked in each position. Mechanical interlocks shall be provided that only permit movement of the carriage whilst the main circuit contacts are in the 'OFF' position. It shall be possible to test the control circuits of an ACB with it partially or fully withdrawn.
- 4.1.9 As a withdrawable ACB or MCCB is being withdrawn, padlockable safety shutters shall automatically cover over the supply side and the load side fixed connections. These shutters shall be capable of independently being opened for testing purposes.
- 4.1.10 One (only) handling truck shall be provided suitable for each type of withdrawable ACB or MCCB supplied as a part of the Assembly, or as a part of any other Assembly supplied to the same building housing the Assembly.
- 4.1.11 Special maintenance tools, where required, shall be provided with each breaker.
- 4.1.12 Cables connected directly to CB terminals will generally not be permitted. Adequately sized cable/busbar adapters shall be provided.

4.2 Switch-disconnectors

- 4.2.1 The switch shall be suitable for the continuous rated duty of the circuit it controls.
- 4.2.2 The utilisation category of the switch-disconnector shall be AC23 for motor switching duties, and AC22 for switching of mixed resistive and inductive loads, with an appropriate utilization category (A for frequent switching and B for infrequent switching).

- 4.2.3 Rotary switch-disconnectors shall be provided with a 'break-before-make' operation for each pole. The rotary switch, or changeover switch formed by the proprietary interlocked interconnection of two switch-disconnectors or fuse switches, shall incorporate a centre 'off' position.
- 4.2.4 Switch-disconnectors for motor starter or variable speed drive duties, that incorporate a test position, shall enable the control circuit supplies while ensuring isolation of the main supply.

4.3 Fuse switches

- 4.3.1 Fuses and fuse bases shall comply with the requirements of SANS 172, and shall be provided with an indicating device to show the "blown" state of the fuse.
- 4.3.2 Only Motor circuit fuse links as defined in BS 88 shall be permitted on motor starting circuits.
- 4.3.3 Fuse current ratings shall be indicated on engraved 20 x 12 mm white-black-white traffolyte labels in 4 mm figures. The labels are to be fitted at the fuse bases and shall not be obscured by wiring.
- 4.3.4 This shall comprise a moulded carriage accommodating either HRC fuses or solid links, and shall provide for a switched neutral where required.
- 4.3.5 Provision shall be made for the following:
- a) Double break contacts on each pole.
 - b) Arc barriers on each pole.
 - c) IP2X protection in either state.
 - d) Silver plated copper contacts.
 - e) Neutral link where required.
 - f) Mechanically operated ON/OFF indicator.
 - g) Auxiliary switch facility.
 - h) Full interchangeability of equivalent rated units
- 4.3.6 The continuous thermal rating and the circuit fuse rating shall be indicated adjacent to the switch.
- 4.3.7 The minimum utilisation category of the fuse switch shall be AC23 for motor starting duties, and AC22 for power distribution only duties.
- 4.3.8 All fuses used on LV circuits shall be HRC cartridge type fuse links complying with both SANS 60269 and BS 88 Part 6 / BS 88 Part 2 Section 2.2 (fuse links with bolted connections), except as follows:
- a) semiconductor protection fuses recommended or provided by the manufacturer of any power electronics incorporated into the Assembly;
 - b) sub-distribution fuses for extra-low voltage control circuits in ICA equipment compartments.
- 4.3.9 The sub-distribution fuses for control circuits (mentioned above) shall be miniature ceramic cartridge fuses complying with BS 2950. They shall be mounted in knife-edge ('swinging blade') disconnect type DIN rail mounted terminals. Knife-edge disconnect type terminals shall similarly be used for neutral links.
- 4.3.10 Neutral and earth link holders shall be non-interchangeable with fuse holders, and fuse and link holders shall be segregated according to circuit voltage.

- 4.3.11 Where HRC cartridge type fuse links do not form an integral part of an item of equipment such as an enclosed transformer, a fuse switch, etc., they shall be mounted in all-insulated fuse carriers fitted into fuse holders. An associated neutral circuit shall be provided with a solid copper link, which shall be mounted in an identical manner adjacent to the phase circuit fuse holders.
- 4.3.12 Fuse and link bases shall contain insulating shrouds, that can only be removed using a tool. A fuse or link shall only be capable of insertion into its base using the appropriate carrier. Fuse and link carriers and holders shall be coloured as follows:
- a) fuse links: black
 - b) neutral links: white
 - c) earth links: green
- 4.3.13 A spare set of all fuse types and ratings used within a functional unit shall be mounted within each functional unit.
- 4.3.14 Combination fuse switches shall comply with SANS 152 and shall be of the independent manual operation type and shall afford minimum protection of IP21.

4.4 Switch operator

- 4.4.1 Switch operating mechanisms shall include operators for fuse switches, switch-disconnectors, moulded case circuit breakers and motor protection circuit breakers for Assemblies.
- 4.4.2 Switch operating mechanisms shall be door mounted and the switches shall be fixed mounting.
- 4.4.3 Switch operating mechanisms shall positively engage with the switch shaft when the door is fully closed and shall be so interlocked with the door so that:
- a) It shall not be possible to gain access via a cover or door to any live points unless the switch is in the open position.
 - b) It shall not be possible to re-close the door or cover unless the switch is in the open position. Operation of the switch with the door open is permissible.
- 4.4.4 Clear indication shall be given, both with the access cover or door open or closed, as to whether the switch is in the open or closed position. Colour indication alone will not be acceptable.
- 4.4.5 Operating handles shall be pad lockable in the “off” / “open” position. The mechanisms shall accept not less than two padlocks each having a shackle diameter of 6 mm.
- 4.4.6 Any isolator mechanism extension shafts shall be provided with guide brackets as necessary to prevent excessive shaft deflection.

4.5 Contactors, Relays and Timers

- 4.5.1 Contactors and relays shall be selected so as to be suitable for the foreseeable operating duty (utilisation category) and operational frequency. They shall operate reliably under reduced voltage conditions by closing (i.e. pulling in and holding) at 85 %, and remaining closed at 60 %, of the rated coil voltage, and shall be suitable for continuous operation at 110 % of the rated coil voltage.
- 4.5.2 Contactors shall comply with SANS 60947-4-1, and shall be electro-magnetically operated air-break multi-pole block type construction. They shall readily accept a wide variety and configuration of auxiliary contact blocks, which shall have their terminals protected to IP2X.

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- 4.5.3 Relays and timers shall be totally enclosed plug-in devices. The bases shall be keyed in order to differentiate between differing relays and timers, and their differing coil / electronics operating voltages, and to prevent incorrect insertion. Bases shall be fitted with retaining clips, and each relay / timer shall have its pin configuration printed on the side of its casing.
- 4.5.4 Relay / timer bases shall have screw clamp type terminals protected to IP2X, which shall be accessible with a screwdriver whilst the relay / timer is plugged in.
- 4.5.5 Relays shall be provided with a transparent enclosure, visual indication that the relay is in the energised and closed state, and a manual test button.
- 4.5.6 Timers shall operate electronically or be synchronously driven, and shall be provided with linearly calibrated time interval scales. The smallest indicated time interval shall be 10 % (or less) of full scale, with a repeatability of 1 % (or better) of full scale. Timers shall be provided with 'energised' and 'timed out' indicators.
- 4.5.7 Where timers require to be viewed by operators, they shall be flush front of panel mounted behind a transparent lockable cover.
- 4.5.8 Contactors shall be satisfactorily withstand the thermal and dynamic effects arising from the magnitude and duration of through fault currents dictated by the characteristics of the associated protective devices and shall be selected in accordance with the kW/current rating.
- 4.5.9 Contactors shall be triple-pole electromechanically operated air-break type, held in or latched pattern as specified.
- 4.5.10 Contactors shall be classified as utilisation category AC3 uninterrupted duty for motor starting and as utilisation category AC1 intermittent duty, Class 1, 60 % for heater duty.
- 4.5.11 Contactors shall be fitted with the required auxiliary contacts. These shall be rated at not less than 6 A and shall be positively driven in both directions.
- 4.5.12 Auxiliary relays for control purposes shall be of the multiple pole type and shall preferably possess the feature of field convertible contact configuration.
- 4.5.13 Plug-in type relays shall have:
- a) Positive-acting mechanical retaining clips. Contact friction alone as a retaining method is unacceptable.
 - b) A keyed member on plug and socket sides to prevent incorrect insertion.
 - c) Clear and indelible markings on both the relay and its base indicating the circuit reference in conformity with the associated circuit and connection diagrams.
- 4.5.14 Auxiliary time delay relays shall be of electronic or synchronous motor-driven type and the time setting shall be infinitely adjustable over the range of 5 - 100 % of the maximum delay. Timing relays deriving the delay function by thermal or pneumatic means will not be acceptable.
- 4.5.15 Auxiliary relays shall have a minimum of 4 individual contacts and shall preferably have the facility to add an extension block with an additional four (4) individual contacts.

4.6 Control switches and pushbuttons

- 4.6.1 Control selector switches shall be of a rotary spring loaded type, with an AC11 rating, and shall have clearly identified switch positions. Where switches are lockable, the key shall be held captive in the abnormal or over-ride position.

- 4.6.2 Pushbuttons shall comply with SANS 60947-5-1 and shall be of a 22 mm diameter, flush bezel type.
- 4.6.3 Emergency stop pushbuttons shall be of a mushroom headed push to stop, stay-put and twist-to-release type. Key type release buttons shall not be used.
- 4.6.4 Pushbuttons shall be coloured as follows:

Table 3: Pushbutton colours

Function	Colour
Start	Green
Stop	Red
Reset	Black
Emergency stop	Red
Lamp test	Black
Close / Down	Green (or black)
Open / Up	Green (or white)
On	White (or green)
Off	Black (or white)
Forward	Green (or white)
Reverse	Green (or black)

- 4.6.5 Pushbuttons shall be of the one-hole fixing, oil tight pattern.
- 4.6.6 Operators (and the mating holes) shall be keyed to prevent rotation of the assembly in the panel.
- 4.6.7 Contacts shall be adequately rated for the circuit duty but shall not be less than 10 A, 230 V AC or 120 V DC rating.
- 4.6.8 In addition the operator shall carry an internationally acceptable symbol indicating its function or shall have mounted immediately above it a clear legend of its function or action.
- 4.6.9 Operators initiating a motion or circuit closure shall be flush with the surrounding bezel, while operators stopping a function or opening a circuit shall project beyond the bezel.
- 4.6.10 Operators providing a selective function e.g. local/remote or auto/manual, shall operate in a semi-rotational manner with equal angular displacement about an imaginary vertical centre line.

4.7 Indicating lamps

- 4.7.1 Indicating lamps shall be suitable for use on either 230 V AC or 24 V DC control supplies, and shall be light emitting diode (LED) type. Lamps suitable for use on 230 V AC shall incorporate a step-down transformer. Indicating lamps shall be continuously rated for a voltage of 10 % in excess of the rated voltage.
- 4.7.2 Lamps shall comprise 22 mm diameter units incorporating either a multi-cluster array of LEDs or a single high intensity surge protected LED; replaceable from the front of panel without any special tools.
- 4.7.3 Indicating lamps shall render good visibility under conditions of an ambient illumination level of 400 Lux.
- 4.7.4 Lamps shall be provided with one of two indicator lamp colour coding schemes as follows:
- a) a primary colour coding scheme, in compliance with IEC 60073, or

- b) a secondary colour coding scheme; which although not standard, is required in order to harmonise with existing operational equipment.

4.7.5 Unless detailed otherwise in the Project Specification, the Assembly shall be provided with indicating lamps coloured in accordance with the primary colour coding scheme, which shall be as follows:

Table 4: Primary colour coding scheme

Function	Colour
Dangerous condition	Red
Emergency / hazardous condition	Red
Emergency stop operated	Yellow
Impending critical condition	Yellow
Alarm / abnormal condition	Yellow
Tripped / fault condition	Yellow
Warning	Yellow
Normal condition	Green
On	Green
Running	Green
Closed condition	Green
Mid position / mid travel	Green + White
Open condition	White
Available / auto available	White
General indication / monitoring	White
Mandatory operation required by operator	Blue

4.7.6 Where specified in the Project Specification, the manufacturer shall supply an additional number of loose indicating lamps (or their coloured lenses) of a specified type and coloured in accordance with the primary colour coding scheme, and shall retrofit these to specified existing assemblies.

4.7.7 Where an Assembly is provided that incorporates lamp colours in accordance with the secondary colour coding scheme, the manufacturer shall also supply an additional quantity of loose indicating lamps. There shall be a sufficient quantity of the required types and colours; coloured in accordance with the primary colour coding scheme, to permit a third party to retrofit them the Assembly at a later date in order to bring it into compliance with the primary colour coding scheme. In addition, the final drawings for the Assembly shall not detail the colour of any indicating lamp that does not comply with the primary colour coding scheme.

4.8 Power measuring instruments and current transformers

4.8.1 The Project Specification states which functional units shall be provided with power/current and voltage measuring instruments, the type, and the facilities required.

4.8.2 Display instruments used to indicate voltages and currents shall normally be analogue instruments, shall comply with IEC 60051, be of the low-impedance type and have an accuracy class of 1.5. They shall be flush front of panel mounted with a 90° quadrant minimum scale length, and be DIN96 size for power distribution functional units, and DIN96 or 72 sized for motor starter functional units.

4.8.3 External zero adjustment shall be possible on all indicating instruments to facilitate adjustment without dismantling the instrument.

4.8.4 Instruments shall be scaled to 120 % of the anticipated designed indication. Ammeters shall be provided with compressed scales to accommodate motor starting or other in-rush

currents, and ammeters monitoring motor currents shall be provided with an adjustable red pointer to indicate full load current.

- 4.8.5 Meters and relays shall be capable of withstanding, without damage, the secondary currents associated with the maximum available through fault current.
- 4.8.6 Instruments shall be provided with shrouded connections to their rear, and ammeter circuits with a full scale deflection in excess of 25 A shall be connected via current transformers (CTs). Apart from CT and ammeter circuits, instrument circuits shall be fused.
- 4.8.7 Instruments used in power distribution circuits shall be flush front of panel mounted and shall provide selectable front of panel digital display of at least the following measurements:
- voltage between phases and between phases and neutral
 - current in each phase
 - power (kW)
 - kVA
 - power factor
 - consumption (kWh)
- 4.8.8 They shall provide data output signals for presentation to PLC, SCADA, telemetry, etc.
- 4.8.9 Where the Project Specification indicates that instruments shall provide fieldbus communication with a control system, this shall be via an open protocol compatible with the proposed control system.
- 4.8.10 Run hour meters shall be of a 5 digit minimum non-re-settable odometer type, with visual indication of operation, and a minimum resolution of one hour.
- 4.8.11 Current transformers (CTs) shall be air insulated, shall comply with SANS 60044, and shall have short circuit ratings in excess of those prevailing at the point of connection. They shall bear individual rating plates, which shall clearly identify the winding polarities (primary or secondary), together with the connection details of any multi-ratio windings.
- 4.8.12 Current transformer accuracy classes shall be selected as follows unless otherwise indicated on single-line diagrams:

Table 5: Transformer accuracy classes

Type of circuit	Class	Comments
Indication	3 or 5	To match the % accuracy of the instrument
Measurement	0.5 or 1	To match the % accuracy of the instrument
Motor protection	10P10	Or as required by protection device manufacturer
Power system protection (e.g. IDMTL)	10P20	Or as required by protection device manufacturer
Power system unit protection (high accuracy; e.g. REF, generation, unit protection)	PX	As specified by protection device manufacturer

- 4.8.13 One pole of the secondary winding of each CT (or group of CTs) shall be connected to earth via a link. All connections to the CT secondary winding shall be made via a proprietary shorting terminal test block. Provision shall be made for attaching test links.
- 4.8.14 Current transformers shall be of the low-impedance type and shall, where ratio, class and output requirements permit, preferably be of the ring-type bar-primary design.

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- 4.8.15 Current transformers shall be rated to withstand the thermal and magnetic stress resulting from the maximum available through fault current.
- 4.8.16 Bridging terminals for current transformers shall be provided at the outgoing terminals where external connections are required. In addition, terminal blocks shall be provided to permit secondary injection tests on protective relays.

4.9 Control-circuit and auxiliary supply transformers

- 4.9.1 Voltage transformers shall be designed, constructed and tested in accordance with the requirements of SANS 60044.
- 4.9.2 Voltage adjustment over the range 95 - 105 % of nominal ratio shall be provided by off-circuit tapings.
- 4.9.3 Transformers shall be provided with isolating switches on the HV side and with protection on both the HV and LV sides.
- 4.9.4 Voltage transformer primary and secondary windings shall be protected by fuses.
- 4.9.5 The protection on the HV. side shall be rated sufficient to withstand inrush currents.
- 4.9.6 Control transformers shall be rated as follows:
- a) Sum of sealed-in burden of all contactors, relays, timers and lamps fed from that unit; plus
 - b) Pickup burden of largest Contactor fed from that unit; plus 10 %.
- 4.9.7 The regulation on closing the largest circuit with all the loads except that of the largest load, or if there is more than one, one of the largest loads, imposed on the transformer, shall not exceed 5 %.
- 4.9.8 One side of the transformer secondary winding, or the star point thereof, shall be connected to earth via a removable bolted link.
- 4.9.9 Voltage transformer nameplates shall be fixed in a position so that details can easily be read when fitted in the cubicle.

4.10 Capacitors

- 4.10.1 Capacitors shall be of the non-toxic, dry, self-healing, metallised film type, and comply with SANS 60831.
- 4.10.2 Capacitors shall be fitted with a means of electrical discharge to reduce the residual voltage to less than 60 V within 5 seconds of being switched off.

5. MOTOR STARTER FUNCTIONAL UNITS

5.1 General requirements

- 5.1.1 Motor starter functional units shall be provided as indicated on the single-line diagrams and as detailed in the Project Specification, and all equipment, components, and wiring shall be included to achieve the required functionality. The following methods of motor starting shall be considered, where the selection is the Contractor's responsibility, to provide the required functionality:
- a) direct on line (DOL)
 - b) star/delta (open/closed transition to suit application)
 - c) line reactor
 - d) auto-transformer (closed transition)
 - e) soft starters and variable speed drives using power electronics
- 5.1.2 Where specified in the Project Specification, integral direct on line starters complying with SANS 60947-6-2, shall be used for motor starters of less than 10 kW. The integral motor starter shall incorporate an isolation device, a short circuit protective device, a contactor and overload protection with Type 2 coordination.
- 5.1.3 Each motor starter shall be provided with an isolation and short circuit protection device.
- 5.1.4 Motor starter contactors, short circuit protective devices, and thermal overloads shall be selected so as to provide Type 2 Co-ordination in accordance with SANS 60439-4-1. The minimum starter contactor utilisation category shall be AC3.
- 5.1.5 Motor circuit residual current protection shall only be provided where necessary to discriminate with upstream protection, where the power supply is derived from a TT source, or where specified in the Project Specification.
- 5.1.6 Contactors used where simultaneous closure would be dangerous, e.g. in reversing, star-delta, or closed transition starters, shall be provided with both mechanical and electrical interlocks.
- 5.1.7 Where components with short time ratings are used, e.g. resistors, transformers, etc., they shall be provided with hardwired temperature monitoring circuits, arranged to trip the line contactor if their thermal limits are reached.
- 5.1.8 Withdrawable starters shall be provided with suitable interlocks to prevent chassis withdrawal or insertion when the starter isolation device is in the "on" position.

5.2 Functional requirements

- 5.2.1 Every individual motor starter unit shall include all equipment, components and wiring necessary to safely and reliably operate the driven plant item. It shall be possible to manually operate plant item from the front panel of its functional unit, notwithstanding any failure or de-selection of any automatic control system, networking / communication facility, PLC, SCADA, or telemetry system. In order to achieve this, the appropriate push buttons / keypads and indicators shall be provided front of panel.
- 5.2.2 If the power supply fails whilst a motor is running, the line contactor shall open. On restoration of the power supply, the motor starter shall immediately be made available to re-start the motor without manual attendance or intervention on receipt of a start command (be it initiated manually or automatically). However, where a hardwired automatic control facility is available, a power-on delay timer (adjustable between zero and 60 s) shall be provided in the hardwired circuit.

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- 5.2.3 Where a 'healthy' signal is required, it shall confirm that the functional unit isolation device is closed, the starter control supply is healthy, no fault condition exists, emergency stop(s) are released, the local isolator (where fitted) is closed. The 'healthy' signal shall be used to provide the 'drive available' input signal to any automatic control schemes or automatic duty selection routines.
- 5.2.4 Each functional unit shall provide any automatic control schemes (including auto duty selection routines) with the following status signals as a minimum, as well as all others as specified in the Project Specification:
- a) Manual/auto mode
 - b) Running
 - c) Tripped
 - d) E/Stop activated
- 5.2.5 Each motor starter shall be provided with an emergency stop circuit, which together with its components shall comply with BS EN 418. A field 'twist to reset' emergency stop button shall be provided. On operation of the emergency stop circuit, the motor line contactor shall immediately open, and the emergency stop circuit shall lock out until it is reset. A front of panel 'emergency stop operated' indication lamp and a status signal for PLC monitoring shall be provided. A composite starter may have a common emergency stop circuit controlling all of its constituent drives.
- 5.2.6 Where identified in the Project Specification, specific process or driven plant interlocks shall be hardwired into the motor starter, and when operated, shall stop and inhibit the drive.
- 5.2.7 Front of panel pushbuttons shall be provided for manual start (forward, and where applicable; reverse), and manual stop. A front of panel control selector switches shall be provided for 'Manual / Off / Auto' or 'Remote / Local' as specified in the Project Specification.
- 5.2.8 Front of panel indicator lamps shall be provided for 'running' and 'tripped', and an ammeter shall be provided for motor circuits ; other front of panel indications e.g. specific fault indication lamps , hours run meter, number of starts counter, etc. shall be as specified in the Project Specification.

5.3 Motor protection

- 5.3.1 As a minimum, every motor starter circuit shall be provided with a thermal overload unit connected to monitor the current in each energised winding of the motor. Unless otherwise specified in the Project Specification, motors of over 30 kW shall be provided with electronic overload protection, and motors of over 75 kW shall be provided with electronic motor protection relays. Intelligent multifunction electronic relays shall be provided if specified in the Project Specification.
- 5.3.2 Thermal overloads shall be scaled and adjustable such that the motor rated current is mid-range, and shall provide a temperature compensated thermal element for each supply phase to the motor. The unit shall provide single phasing protection, and incorporate auxiliary tripping contacts with a manual test facility. The unit shall be capable of being manually or automatically reset (set to auto). Unless otherwise specified in the Project Specification, thermal overloads shall be trip class 10.
- 5.3.3 Electronic overload units shall incorporate the features required of a thermal overload, together with provision for the adjustment of tripping and reset times. In addition, stalled rotor protection shall be provided, together with integral thermistor protection where required. Where required, electronic overloads shall be suitable for use in conjunction with power electronics (soft starters or variable frequency converters).
- 5.3.4 Electronic underload protection shall be provided for all centrifugal pump, fan, or directly driven mixer motor circuits above 30 kW. When detecting underload, the device shall



measure the true motor power (and not just the phase angle), shall be configured to detect an unloaded running motor condition, and shall incorporate start delay, motor trip, and manual / auto reset (set to auto) facilities. The unit shall incorporate a digital percentage load display.

- 5.3.5 Where required on drives of less than 30 kW, the underload unit shall be provided with overcurrent protection providing the same facilities as a thermal overload. When required on larger drives, underload protection shall be provided as an integral part of an electronic overload or motor protection relay, and where applicable shall be suitable for use in conjunction with power electronics.
- 5.3.6 Motor thermistor and RTD (PT100) relays shall be provided for motors which have been specified to be fitted with thermistors or RTDs.
- 5.3.7 Motor starter functional units for immersible/submersible pumps shall incorporate all the standard integral motor and pump protection, such as water ingress, temperature of windings and bearings, vibration, etc.
- 5.3.8 All protection devices shall operate in a fail safe manner via electrically maintained relays which de-energise on a fault condition. On sensing a trip condition, the devices and relays shall electrically lock-out the emergency stop circuit, and shall be reset manually using a front of panel common fault reset pushbutton. In addition, they shall automatically reset on control supply switch on and upon power restoration in the event of a power loss.
- 5.3.9 Electronic motor protection relays and digital overload and underload devices which provide operator interfaces shall have front of panel mounted displays and controls.

5.4 Test circuits

- 5.4.1 The motor starter control circuit supply shall be provided with a functional test facility, whereby the functionality of the control circuit and its equipment and components can be fully demonstrated with the compartment door(s) open, but whilst the motor circuit supply remains isolated at the functional unit isolating device.
- 5.4.2 A control selector switch shall be provided for 'Normal/Test' selection inside the relevant compartment
- 5.4.3 The test supplies shall be arranged to be de-energised when the motor circuit supplies are energised. The test supply shall be provided with short circuit protection, and shall be capable of isolation.

6. BUSBAR AND BUSBAR TRUNKING

- 6.1.1 The main distribution circuit through the Assembly shall comprise a main and distribution busbar system, comprising of 3 phase and neutral busbar system. The rated current of the busbar system shall match the rating of the main incomer
- 6.1.2 All main and distribution busbars, risers and droppers shall be air-insulated and shall be fabricated from hard drawn, high-conductivity copper. Aluminium busbars will not be permitted. Busbars shall be tinned for waste water treatment works (WWTW) applications. If pre-tinned copper work is provided, cut surfaces may remain bare, providing the current path is unaffected and suitable contact lubricants are used before tightening joints.
- 6.1.3 Main busbars shall be enclosed together within the top of the Assembly. No other conductors shall be run in the busbar compartment. Access to the busbars shall be through covers, requiring the use of a tool for removal. All internal fixings shall be held captive. No components shall be placed in a busbar compartment.
- 6.1.4 Main and distribution busbars shall be continuous over each section, extending to over the full length of the Assembly with the same current rating and cross-sectional area throughout their length.
- 6.1.5 Main busbars, distribution busbars and all flexible connections, shall be adequately sized, braced and supported to withstand any electromagnetic forces and thermal effects to which they may be subjected, including the occurrence of fault currents, up to the full fault levels specified.
- 6.1.6 The vertical riser buses shall be copper full height and rated for the section total load. Small openings in the vertical barriers shall permit the plug-on control unit contacts to pass through and engage with the vertical bus bars. Unused plug-on openings in the vertical barriers shall be equipped with plastic snap-in closing plugs.
- 6.1.7 All busbar connections shall use joints secured against loosening. Joints and Tee-off connections in busbars shall be made by means of high-tensile bolts, nuts and approved locking washers. A minimum of two such bolts shall be used per joint or tee. The joints shall not be taped in order to facilitate visual inspection and checking of bolt tensions. The joint contact areas shall be smooth, very flat and polished or tinned for dry jointing.
- 6.1.8 Busbars shall be provided with phase colour markers, red, white, blue (and black in the case of four wire systems). Such colour identification may take the form of coloured bands at intervals along the busbar run of not more than 800 mm. The combined width of the colour bands per phase shall not be less than 300 mm per 800 mm busbar length. The use of the convention, Red, Rear, Right shall be employed
- 6.1.9 The maximum length of any cable connections from a busbar shall be 1000 mm.
- 6.1.10 A cabled 'busbar' system of the specified radial or closed ring arrangement may be offered as an alternative to a conventional system if:
 - a) The Assembly has a rated short-time withstand current or rated conditional short-circuit current not exceeding 10 kA; or
 - b) The Assembly is protected by current limiting devices having a cut-off current not exceeding 17 kA at their rated breaking capacity.
- 6.1.11 This will generally mean that the rated current of such an Assembly will be less than or equal to 100 A.

7. INTERNAL WIRING AND FIELD CONNECTIONS

7.1 General

- 7.1.1 All wiring within the Assembly shall run directly between terminals, without any joints or other connections. Wiring shall be carried out using multistrand, single-core PVC-insulated copper conductor, 660/1 000 V grade (minimum), to SANS 1507, sized and derated where required for the currents to be carried. Single-strand conductor shall not be used and no conductor shall be less than 1,5 mm² cross-sectional areas.
- 7.1.2 Field wiring connections will be identified by others using the field device tag references. This information will be provided by the Engineer, and the Contractor shall use these field identifiers when identifying the compartment field terminations.
- 7.1.3 Wiring layout shall permit alterations to individual circuits without requiring shut down of the complete Assembly.

7.2 Cable Ways inside Assembly

- 7.2.1 All bus wiring and interconnections between compartments within the Assembly shall be contained within the enclosure, and shall be segregated in wire-ways separate from other compartments. Where such wiring is terminated in a compartment, it shall be segregated from all other wiring in that compartment. All wiring and cabling entering or leaving a compartment or passing through a partition shall do so via a permanently fixed bush.
- 7.2.2 Wiring between components shall be:
- a) carried out in a neat and systematic manner
 - b) contained in non-metallic trunking
 - c) Run to compartment doors in spiral wrapping.
- 7.2.3 Any wire containment system shall securely locate the wiring, and provide 25 % spare capacity on completion. Cableways shall have furthermore sufficient space to enable the installation and removal of any cable without the need to remove any other cable or component. Cableways shall incorporate adequate facilities to locate and support the cables.
- 7.2.4 Wiring on compartment doors shall be similarly supported, and shall be provided with support and protection across the door to compartment side wall transition, whilst permitting the door to be fully opened without straining the wiring. Wiring system accessories shall not deteriorate with heat or propagate flame.
- 7.2.5 Wiring shall be segregated according to need; circuits that enter the compartment without isolation shall be separately segregated and loomed with spiral wrapping and identified. Control circuits shall be wired in twisted pairs or screened cables, and together with data network cabling, shall be physically segregated from power circuits by barriers. If lightning and/or surge protection measures have been used to protect individual circuits, these circuits shall be segregated from the wiring of other unprotected circuits.
- 7.2.6 Cable-ways or chambers shall not contain any equipment or components.
- 7.2.7 Where field cables are terminated other than in the base of the enclosure, cable-ways or cable chambers shall be provided to transport the cables through the enclosure to the compartment or cable box at which they are glanded or terminated. Careful thought should be given to the termination of power cables and their location within the assembly.

7.3 Gland Plates

- 7.3.1 All field cables and wiring shall enter the enclosure through gland plates, which shall be located so as to facilitate the spreading of cable cores.
- 7.3.2 Gland plates shall be rigidly supported and maintain the IP rating of the enclosure
- 7.3.3 Gland plates and cable boxes shall minimise the effects of eddy currents and be suitable for the type of cable used. Single core cable gland plates shall be made of non-magnetising material.
- 7.3.4 Gland plates for bottom access cabling shall be located at least 300 mm above the finished floor level.
- 7.3.5 Each compartment gland plate shall be an integral part of the construction of that compartment

7.4 Identification

- 7.4.1 All wires shall be identified at both ends using colour coded alpha-numeric ferrules. Within a compartment, a wire shall have the same identifier at both ends; and this identifier shall not be duplicated within a functional unit.
- 7.4.2 Components and wiring shall be installed such that the identification of every wire is clearly visible and readily accessible on completion of the Assembly installation at site. Horizontal wiring identifiers shall be read left to right, and vertical wiring identifiers shall be read bottom to top.
- 7.4.3 All conductors shall be identified in conformity with the approved circuit and connection diagrams. No number shall be used more than once in each panel except where electrically identical. Wires/conductors shall have the same number on either end of the wire and all wires which are electrically identical shall have the same wire number
- 7.4.4 Circuit wiring shall be coloured in accordance with the following:

Table 6: Colour code for wiring

Wire colour	Function
Red (white, blue)	Red (white, blue) phase connections in current and voltage-transformer circuits or connections in red (white, blue) phase power circuits
Black	Neutral (star-point) connections whether earthed or unearthed insulated wires
Red / black	Connections in AC control circuits (black = neutral)
Red / black	Connections in DC control circuits (black = negative)
Green and yellow	Earth wires and earthing

- 7.4.5 Power-circuit conductors shall be coloured according to the phase to which they are connected.

7.5 Termination

- 7.5.1 Wiring shall be terminated using crimped cable ends, lugs or any other approved method that is appropriate for the conductor size and type of termination. All of the strands forming the conductor shall be connected at the point of termination. Soldered connections shall only be used on electronic equipment where it is not practicable to use any other termination method.

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- 7.5.2 Wiring with a cross section area of less than or equal to 6 mm^2 shall be terminated in terminals mounted on DIN rail. Wiring with a cross section area of greater than 6 mm^2 shall be terminated in bolted terminals.
- 7.5.3 All wiring entering or leaving a compartment shall do so via terminal rails, with the exception of specialised signal or data circuits, which may be cabled directly to dedicated connections on electronic equipment located at the periphery of the component mounting plate.
- 7.5.4 The conductor shall be clamped in such a manner that the captive clamping screw does not come into contact with the conductor. Alternatively, screw-less spring clamp tensioning terminals may be used to terminate single conductors of up to 10 mm^2 . Conductors of cross-section above 16 mm^2 shall be terminated using stud type terminals; similarly mounted and grouped on DIN rail.
- 7.5.5 No more than two conductors shall be connected to one side of a terminal. Where it is necessary to connect adjacent terminals together, proprietary shorting bars or combs shall be used.
- 7.5.6 Spare cores shall be terminated at both ends or tied back, but shall not be cut short.
- 7.5.7 All terminals shall be protected to IP2X, including stud type terminals; which shall be shrouded to achieve this. Terminals shall be segregated according to function and operating voltage; by grouping or by terminal rail mounted partitions or barriers. All stud type terminals shall be provided with individual segregating barriers.
- 7.5.8 All circuit terminal rails shall include 10 % spare space.
- 7.5.9 Terminals shall be grouped together and segregated according to operating voltage and function by terminal rail mounted barriers. Stud type terminals shall be provided with individual segregating barriers.
- 7.5.10 Terminals shall face the compartment door for ease of connection.
- 7.5.11 Terminals shall be located and spaced so as to enable the easy disconnection and reconnection of conductors, whilst providing sufficient space for the looming and spreading of cable cores. Where practicable, the layout of terminal rails shall be such that cores from the same field cable are not split between non-adjacent groups of terminals.
- 7.5.12 All wiring of external connections shall be brought out to individual terminals on a readily accessible terminal block.
- 7.5.13 All spare contacts are to be wired back to terminals.

8. LOW VOLTAGE EARTHING

8.1 Main incoming earth terminal

- 8.1.1 The Assembly shall incorporate facilities for connecting to the main incoming earth terminal, subject to its location being clearly identified and easily and safely accessible with the Assembly energised. The Assembly earthing system may comprise either an earth bar extending the full length of the Assembly or, for Assemblies with less than or equal to two (2) functional units and a supply rating of less than 100 A, a stud arrangement.
- 8.1.2 Earth bars shall:
- a) be manufactured from high conductivity copper (tinned for WWTW applications);
 - c) be located in a safe and easily accessible position;
 - d) have a minimum number of joints;
 - e) have at least one disconnecting link;
 - f) have facilities for connection to the main incoming earth terminal (the Supply Company earthing system and / or from a local earth electrode system) at each end of the bar, and
 - g) be rated and tested at a minimum of 60 % of the busbar fault withstand capacity
 - h) have a cross-sectional area of not be less than 500 mm², nor less than 50 mm in width.
 - i) be securely connected in each panel or cubicle to bare metal
- 8.1.3 Provision shall be made for the connection for the following connections to the fixed portion of the earth bar:
- a) electrical installation main bonding conductors
 - j) functional earthing conductors external to the Assembly
 - k) equipotential bonding conductors external to the Assembly
 - l) other equipment protective conductors external to the Assembly
 - m) the Assembly main earth bar / circuit, which shall be terminated onto the fixed portion
 - n) an additional 2 No. spare terminations
- 8.1.4 All metallic non-current carrying parts of the Assembly shall be bonded together and connected to the Assembly earth busbar.

8.2 Compartment earthing

- 8.2.1 Each compartment shall include an earth stud connected to the main earth bar or stud by separate connections or by a common vertical earth tape. Earth conductors to each compartment shall be sized to withstand the fault level, subject to a minimum cross-sectional area of 6 mm².
- 8.2.2 The following shall be directly connected to the compartment earthing terminal by earthing conductors with a minimum cross sectional of 4 mm² or braided straps of similar rating:
- a) compartment door
 - b) any removable cover
 - c) component / equipment mounting rails and earth terminals
- 8.2.3 A compartment may contain subsidiary earth terminals or bars to which the following circuits may be specifically connected:

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- a) 'clean' earths from instrumentation circuits and equipment
 - b) functional earths; e.g. from telecommunications equipment
 - c) surge protection earths; e.g. direct connections from lightning protection units

8.2.4 These earth terminals or bars shall be separately connected directly back to the Assembly main earth bar with 6 mm² minimum cross-section conductor.

8.2.5 Cable gland plates associated with a compartment shall be provided with an earth stud, which shall be connected directly to either the compartment earthing terminal, or to the main earth bar, with a conductor of 6 mm² minimum cross-sectional area.

8.2.6 Doors having components mounted on them shall be bonded to the main structure by means of flexible copper earth connection arranged so that it cannot be trapped as the door is opened or closed. Metal hinges shall not be considered sufficient to ensure electrical continuity.

8.2.7 Where cables carry low level high frequency signals, or are installed where there is a significant risk of high frequency interference; (e.g. in signal circuits connected to equipment containing power electronics), they shall where necessary have their screens / braids capacitively connected to earth in a proprietary manner, and proprietary means shall be included to provide 360° earthing for field cable braids / screens.

8.3 Intrinsically safe circuit earthing

8.3.1 If specified on the Project Specification, separate earth bars or studs shall be provided for connecting equipment requiring a clean earth or an intrinsically safe earth directly to the main incoming earth terminal. If required, such earth bars or studs shall be located adjacent to the equipment requiring a clean earth or an intrinsically safe earth, as appropriate.

8.3.2 Where zener diode safety barriers are contained within a compartment, they shall be separately and directly connected to the main earth bar via duplicate earthing conductors; each of 6 mm² minimum cross-section. These conductors shall be clearly identified as intrinsically safe earths.

9. POWER FACTOR CORRECTION

9.1 General requirements

- 9.1.1 Power factor correction capacitors shall be so selected and sized as to raise the lagging power factor due to induction motor loads; either individually or when summated across the Assembly, to a final corrected power factor of 0.97 lagging. When designing the system, the un-corrected power factor for each motor shall be taken as that quoted in manufacturers' literature for a high efficiency motor of equivalent rating operating continuously at its 75% duty point.
- 9.1.2 Capacitors shall be of the non-toxic self-healing dry metallised film type. Every capacitor or group of capacitors shall be provided with integral discharge resistors to reduce the residual terminal voltage to less than 50V within one minute of being disconnected from the supply.
- 9.1.3 Capacitors shall be suitable for continuous connection to a three phase low voltage industrial power supply. If the low voltage power system to which the Assembly will be connected has significant voltage waveform distortion or harmonic content, or has other capacitive or inductive networks (e.g. harmonic filters) connected to it, additional information must be obtained by the Contractor via site surveys.

9.2 Power factor correction for individual drives

- 9.2.1 Where power electronic soft starters are used, the sequence of the connection and de-energising of the capacitors shall be in accordance with the manufacturer's recommendations. Power factor correction shall not be applied to variable speed drive systems.

9.3 Bulk power factor correction

- 9.3.1 Where detailed in the Project Specification, bulk power factor correction shall be provided for the whole Assembly, in a purpose designed functional unit occupying one or more compartments within the enclosure.
- 9.3.2 Capacitors shall be arranged into banks, suitably sized to enable the incremental control of the power factor against a changing load. Each bank shall be automatically contactor controlled, in a manner that minimises switching surges, and capacitor bank status information shall be derived from the contactor auxiliary contacts. A proprietary multi-stage power factor controller, with a minimum of six steps, shall be used to monitor and sequence the switching of the capacitor banks.
- 9.3.3 Where there is provision to supply the Assembly from a generator, automatic means shall be included that will inhibit bulk power factor correction when the generator is in use.

10. POWER ELECTRONIC EQUIPMENT

10.1 Soft starting equipment

- 10.1.1 Soft starters shall comprise a proprietary item of chassis mounted equipment, designed for installation within an Assembly. They shall be rated to continuously carry the intended motor full load current, and provide the required number of starts per hour.
- 10.1.2 The soft starter shall be thermally designed to carry the motor current until the motor protection operates, and where this cannot be guaranteed, high speed semiconductor fuses shall be provided to protect the power electronics. Where such fuses are used, a spare set shall be provided and fixed within the compartment.
- 10.1.3 Soft starters shall be of a digital energy optimising design and shall incorporate appropriate motor protection, and where pumping circuits are being controlled, soft stop features shall be included. When the soft starter has completed the ramped application of motor voltage, a 'top of ramp' signal shall be generated.
- 10.1.4 Soft starters shall incorporate a built-in by-pass contactor rated for the full load running current of the motor, such that on receipt of the 'top of ramp' signal, the by-pass contactor shall close and divert the motor current away from the power electronics. When running in the by-passed condition, the motor shall continue to be provided with the full protection and monitoring features afforded by the motor starter. When a controlled stop command is received, the by-pass contactor shall be de-energised, in such a manner that the control of the motor is transferred to the power electronics.
- 10.1.5 Facilities shall be provided for the emergency stopping of the controlled motor in the shortest possible time. The emergency stop facility shall not be dependent on any software functions within the soft starter or its associated equipment and shall disconnect the soft starter from the supply by means of a full load rated line contactor fitted between the compartment isolation / protective device and the soft starter.
- 10.1.6 Where specified in the Project Specification, connectivity between the soft starter functional unit and other equipment or systems within the Assembly shall be via an open field device network compatible with the proposed PLC control system. It shall preferably use an interface device integrated within the soft starter, so as to provide remote network access to the full range of the soft starter's control and monitoring facilities.

10.2 Variable speed drives (VSDs): General

- 10.2.1 The VSD motor starter shall comprise a variable frequency converter (VFC) , phase shift transformer(s) (where required), and all other components necessary to provide the full speed and torque control of an a.c. cage induction motor over the specified operating speed range up to the motor's rated speed and full load current.
- 10.2.2 VFCs shall either be wall-mounted, housed within a motor control centre or free-standing units within their own enclosures as specified in the Project Specification.
- 10.2.3 Unless otherwise specified in the Project Specification, VFCs shall have uncontrolled rectifiers (i.e. diode front-end) with the specified pulse number (6/12/18). Either a.c. line reactors or d.c. link chokes shall be provided with all 6-pulse VFCs to reduce input current harmonics.
- 10.2.4 Where a phase shift transformer is required to achieve the specified rectifier pulse number, the transformer shall be provided as an integral component of the VSD and, unless otherwise specified in the Project Specification, shall be of the dry type and housed in a dedicated section of the VFC enclosure.

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- 10.2.5 VFCs shall be capable of operating under the service conditions specified in Clause 4 of SANS 61800 Part2, and any unusual environmental service conditions specified in the Project Specification. Functional features and performance requirements shall be in accordance with Clauses 3 and 6 of SANS 61800 Part 2 respectively as varied
 - 10.2.6 The output rating of the VFCs shall be selected to suit the associated motor and shall take into account the operating speed range.
 - 10.2.7 Every VSD motor starter shall be provided with incoming supply isolation and short circuit protection as well as an input contactor if specified in the Project Specification.
 - 10.2.8 The VSD shall provide the specified motor protection either as an integral part of the VFC or by way of a separate motor protection relay.
 - 10.2.9 Where any semiconductor or special d.c. circuit fuses are used in the VFC power circuit, a spare set shall be provided . A list of all fuses, type, ordering code and supplier and supplier details shall also accompany the spare fuses.
 - 10.2.10 The VSD control system shall incorporate comprehensive diagnostics to provide fault supervision and status indication in accordance with Clauses 3.2 and 3.3 respectively of SANS 61800 Part 2 and any additional requirements specified in the Project Specification.
 - 10.2.11 Input/output devices and communication links shall be provided as specified in the Project Specification.
 - 10.2.12 The Contractor shall ensure that the suppliers of the VFC and the associated motors confirm that their standard equipment is fully compatible and, if not, that the necessary equipment design changes (e.g. enhanced motor insulation) and/or supplementary equipment (output filters or reactors) is provided to ensure compatibility.
 - 10.2.13 The Assembly shall permit adequate heat rejection from the VSD compartments and the Contractor shall provide estimates of the total heat rejection from the Assembly. The location of the Assembly and VSD panels, and the ventilation arrangement, shall be as specified in the Project Specification.

10.3 Variable Speed Drives (VSDs): EMC Requirements

- 10.3.1 All VSDS shall comply with the requirements of product standard SANS 61800-3 for Category C2/C3 as appropriate and an EMC filter shall be provided as part of a VFC if necessary to achieve the required electromagnetic compatibility.
- 10.3.2 The supply voltage distortion limits specified in the Project Specification shall be achieved through the use of diode front-end VFCs with higher pulse numbers, active front-end VFCs or harmonic filters. Documentary proof shall be provided with the Tender that the VFC input current harmonics will be limited to the required levels.
- 10.3.3 When specified in the Project Specification, the Contractor shall carry out a harmonic survey at the point of supply to measure background voltage harmonics. The Contractor shall repeat the survey after the commissioning of all VSDs to demonstrate that the actual harmonic performance of the VSDs under worst case operating conditions does not exceed the specified limits.
- 10.3.4 Any VFC input harmonic filters or line reactors and any output filters (i.e. dU/dT, common mode or sine filters) or reactors shall be provided as part of the VFC and shall be included in the supply price. Output filters shall be provided where required to ensure motor insulation compatibility and/or control of bearing currents. Output reactors shall be provided if motor supply cables exceed the allowable length.
- 10.3.5 The design of dedicated VFC input harmonic filters shall take account of the supply impedance provided in the Project Specification, any background voltage harmonics, any

other reactances (e.g. transformers) or capacitors (e.g. power factor correction), or other filters connected to the power system, so as to avoid possible resonance problems.

10.4 Variable Speed Drives (VSDs): Control

- 10.4.1 The VSD control panel / operator interface shall be mounted in the face of the VSD panel/ Assembly. Control parameter adjustment shall be easily achievable by menu-driven option selections, with engineering options protected from unauthorised changes by the use of multi-level password protection.
- 10.4.2 All operator controls and indications shall be available front of panel, either via an operator interface / keypad, or by using discrete push-buttons and lamps, etc.
- 10.4.3 The VFC shall incorporate on-board protection, control and monitoring features, which shall include, as a minimum, the following:
- a) On
 - b) Unit Ready
 - c) Overload
 - d) Failure
 - e) Current limit
 - f) Over voltage
 - g) Manual start and stop
 - h) Raise and lower speed
 - i) Current operating status
 - j) Speed indication
- The VSD shall be such that when set in the 'manual' mode, operation from the control panel / operator interface shall be as follows:
- a) a start command shall cause a normal ramped start up to the pre-set speed
 - b) a stop command shall cause a normal ramped down stop and shutdown of the drive
- 10.4.4 All diagnostic and fault messages shall be stored, whether reset or not and it shall be possible to recall them from the operator interface/control panel.
- 10.4.5 All VFC function parameters shall be programmable from a dedicated keypad, or via a standard programming software package installed on a standard portable notebook. A serial communications port to RS232 / RS485 standard or other network communication port shall be provided for dedicated communication with the VFC, and via which all programmable, control, monitoring and diagnostic functions available locally at the VFC shall be accessible.
- 10.4.6 A copy of the configuration /standard programming software shall be provided with each VSD.

11. CONTROL CIRCUIT SUPPLIES

11.1 Provision of control circuit supplies

- 11.1.1 Fixed pattern functional units shall incorporate individual control circuit supplies that are derived from within the functional unit.
- 11.1.2 Control circuit supplies shall be 230V AC (single pole and neutral) or 24V DC as specified in the Project Specification. They shall be separately derived from double wound transformers, which where practicable shall have 400V primary windings. Double pole primary winding protection shall be provided by fuses or a miniature circuit breaker.
- 11.1.3 The rating of each control transformer shall exceed the sum of the foreseeable maximum continuous load (which for an electromagnetic device shall be the 'hold-in' VA) plus the in-rush current of the largest or simultaneously operating load device(s) (e.g. the 'pull-in' VA).
- 11.1.4 Control circuit supplies shall comply with SANS 60204-1, and the neutral terminal of each transformer secondary winding shall be provided with a removable link, and shall be connected to earth. Secondary winding overcurrent protection shall be provided.

11.2 Control circuit features

- 11.2.1 One pole of every contactor and auxiliary relay coil, timer, etc. shall be connected directly to the neutral (i.e. earthed) side of the control supply. Each control circuit shall be sectionalised and arranged such that where practicable, discrimination is achieved under fault conditions.
- 11.2.2 Where possible, common controls and ICA compartment circuits shall operate at 24V DC, and shall interface with the functional unit 230V AC control circuits by means of 24V DC interposing relay(s) located in the functional units.

12. SIGNS AND LABELS

12.1 General

- 12.1.1 Safety signs and labels shall be provided wherever necessary in relevant languages so as to unambiguously communicate safety and functional guidance to any person who may operate the Assembly or otherwise come into contact with any part of the electrical system forming a part of the Assembly, and shall be provided for the specific identification of every component contained within the Assembly.
- 12.1.2 Signs and labels shall be located in such a manner that:
- a) it is obvious as to the nature and location of the hazards or component(s) to which they relate
 - b) when mounted on any enclosure cover or plate, there is no possibility of that cover or plate being interchanged with any similar item on that Assembly or on any other Assembly supplied to the same site
 - c) they are not fixed to easily removable parts (e.g. trunking covers, etc.), unless their purpose is to warn of the consequences of removing a removable part
 - d) they are at all times adjacent to the item to which they refer, and accommodate situations where components could be moved along a DIN mounting rail
 - e) they will not be obscured by any equipment, components, or wiring, etc.
 - f) they are legible and will remain easily read throughout the life of the Assembly
 - g) Signs and labels shall be securely and permanently fixed using an appropriate number of corrosion resistant, mechanical fixings. The fixing of labels, safety signs and notices shall not affect the IP rating of the Assembly.
- 12.1.3 Short individually fixed labels covering several items only, shall be used in lieu of long multi-legend labels; e.g. above a row of indicator lamps.
- 12.1.4 Self-adhesive, vinyl safety signs may be used if there is no requirement for special legend and propriety safety signs are available.
- 12.1.5 Safety signs and labels shall be of such size that the legend thereon is clearly legible from the operating position (or a 3m distance), and the pictograph and its accompanying text shall be chosen so as to provide the appropriate communication in an explicit and unambiguous manner.
- 12.1.6 Safety signs and labels fixed to the outside of the enclosure shall be manufactured from 1.5mm thick anti-reflective polycarbonate with the legend reverse screen printed, or alternatively from 3mm thick bevel-edged clear perspex rear engraved with black characters. Internal labels may be manufactured from a laminated plastic material which shall normally provide a black legend against a white background. Where specifically agreed with the Engineer, internally mounted labels and charts, e.g. for distribution boards, etc., may be of permanently printed plastic, plastic laminated thin card, or thin card protected behind perspex.

12.2 Safety Signs

- 12.2.1 As a minimum, safety signs shall be fitted to removable covers over busbars and live connections, and to doors of compartments containing:
- a) incoming supply cable termination points
 - b) internal switching and isolation devices

- c) incoming or internal means of isolation; stating the highest voltage controlled by the means of isolation
- d) functional units incorporating capacitors
- e) more than one supply or multiple control circuits originating elsewhere
- f) equipment located in a 'safe area' but associated with certified apparatus located in a hazardous area; a sign shall also be fitted at the safe area cable termination rail.

12.2.2 A safety sign identifying the operating voltage shall be placed in any compartment where there is equipment, components, or wiring, that can be energised at above extra low voltage.

12.2.3 Where there is no suitable standard symbol or pictograph, an application specific sign may be produced using simple and appropriate symbols, pictographs, and text, to indicate the hazard in a simple and straight forward manner that is acceptable to the Engineer.

12.2.4 Multipurpose signs shall be used where there is a need to communicate multiple hazard messages.

12.3 Labelling

12.3.1 The text of every label, excluding individual internal component identification labels, shall be as agreed with the Engineer.

12.3.2 Every Assembly shall be provided with a name plate detailing the following:

- a) Manufacturer's name or trademark
- b) Manufacturer's contact details
- c) Manufacturer's type designation, serial / identification number
- d) Date of manufacture
- e) Rated operational voltages, frequencies, and number of phases
- f) Continuous busbar rating
- g) Short circuit withstand current and duration
- h) IP rating

12.3.3 An application name shall be prominently displayed on the Assembly, as detailed in the Particular Specification.

12.3.4 Each compartment shall be identified with a designation label which shall include the full plant functional name and the alpha numeric reference cross referenced to as-built drawings and documentation contained in the Operation and Maintenance Manual. For rear access Assemblies, a duplicate designation label, mounted adjacent to the gland box, shall also be provided at the rear of each compartment.

12.3.5 The material used shall be selected having regard to the size and fixing methods of the label and the label shall not warp in service. Labels mounted on the outside of the Assembly shall rectangle in form and be manufactured of either:

- a) Laminated plastic, engraved so as to produce black letters on a white background
- b) Engraved sandwich board ("Trifoliate", "Darvic" or equal)
- c) Reverse engraved acrylic material ("Perspex") with filled letters and reverse sprayed

12.3.6 For outdoor applications (where specified) labels shall be brass or aluminium (with letters filled in black), lightly sanded with fine grit paper and clear lacquered

12.3.7 Labels for door mounted components and labels used inside the Assembly shall be to the same standard or may alternatively be printed using an approved, propriety system.



12.3.8 Text characters shall be uniform in height, in upper case (except where standard abbreviations of units are used, e.g. kWh, kVA, etc.) and of the following minimum dimensions:

- a) application labels: 8mm
- b) compartment designation labels: 6mm
- c) information or warning labels: 6mm
- d) component identification labels: 3mm

12.3.9 All components shall be clearly labelled. Internal components shall be clearly identified by individual labels to indicate the equipment to which they relate. The component identification labels shall correlate with the Assembly drawings and documentation. If this is not practical due to space restrictions, common labels (e.g. diagrams may be used).

12.3.10 Current transformers shall be provided with separate and individual identification and rating plates.

12.3.11 Each distribution board shall be provided with a circuit chart laid out in a way that matches the orientation and layout of the protective devices in the distribution board.

12.3.12 A typed circuit chart shall be permanently fixed inside each Assembly or immediately adjacent to the distribution board. The chart shall be laid out in accordance with the physical arrangement of the protective devices that it is easy to relate the circuit chart details to the appropriate protective device. As a minimum, the chart shall be enclosed in a transparent protective cover attached to the inside of the compartment door.



13. INSTALLATION REQUIREMENTS

13.1 Shipping

- 13.1.1 Assemblies shall be shipped in sections to facilitate field handling for transportation and installation. The shipped sections shall be joined together to form a complete unit assembly.
- 13.1.2 Preparation for shipment shall protect the Assembly auxiliary devices accessories, etc. against corrosion, breakage or vibration injury during transportation and handling.
- 13.1.3 Disassembly shall be into the largest components or sub-assemblies possible, consistent with packing, road transport and handling limitations.
- 13.1.4 All parts shall be clearly and lastingly match marked to facilitate field erection prior to disassembly and packing for transport. Instructions shall be provided for reassembly of sections in the field or accompanied by a qualified representative from the Assembly Manufacturer.
- 13.1.5 The Contractor shall be responsible for delivery including loading and unloading of all equipment to site.
- 13.1.6 The Contractor shall provide information (in time) regarding specialised handling and storage requirements/techniques for equipment on the site until finally installed in the operating location.

14. LOCAL CONTROL PANELS

14.1 General requirements

- 14.1.1 The START/STOP pushbutton or control station shall be mounted adjacent to the drive.
- 14.1.2 The enclosure incorporating the pushbuttons, selector switches and indicating lights shall be fully water, weather and vermin-proof and shall have a minimum rating of IP65. The enclosure shall be manufactured from 3CR12 and shall be painted B26 to SANS 1091.
- 14.1.3 All pushbutton control station shall be pedestal mounted on a bracket at least 1 000 mm above ground/floor level.
- 14.1.4 All START pushbuttons shall be green and the operator shall be flush with the surrounding bezel.
- 14.1.5 All STOP pushbuttons shall be a red mushroom head latching push button and shall serve as an emergency stop.
- 14.1.6 All selector switches shall be rotary selector switches with black operators.
- 14.1.7 The control/pushbutton station shall be adequately designed to provide space for the following:
 - a) The required pushbuttons, selector switches and indicating lights complete with their appropriate labels.
 - b) Termination of all control wiring associated with the drive or group of drives. The minimum terminal strip length is 150 mm. A single multicore control cable shall be installed from the Assembly to the station, from where the required signals will be individually wired.
 - c) Stations for submersible equipment shall in addition of the required control cables, also provide for the termination of all the required power cables.
 - d) Sufficient space shall be provided for the glanding of the required cables.
- 14.1.8 All further requirements pertaining to the design, construction, installation and commissioning of control panels (e.g. Labelling, earthing, commissioning, etc.) shall be as specified in the relevant subsections of this Specification.

14.2 Start/Stop pushbutton stations

- 14.2.1 In addition to the above general requirements, START/STOP pushbutton station shall confirm to the following additional requirement:
 - a) One START pushbutton
 - b) One STOP pushbutton., The STOP pushbutton shall be twist to release.
 - c) Where reverse local control is required the reverse button shall not latch unless required.

15. FUNCTIONAL DESIGN

15.1 Specification to the Contractor

The Engineer shall provide the Contractor with the following information, which will form the basis for the design of the Assembly:

15.1.1 The Particular Specification

The Project Specification will detail all project specific requirements.

15.1.2 MCC and Local Control Table

The MCC and Local Control Table will be a schedule of all external connections and their function, ratings, etc. It gives an indication of each load's kW rating and the relevant circuit breaker size that must be selected. Also stated will be the type of starting, the local visual indication and the requirements for manual, automatic and local control needed.

15.1.3 I/O Schedule

The I/O Schedule will detail all the input and output signals (analogue and digital) for the controller connections, and the relevant equipment part it connects to.

15.1.4 Technical Data Sheets

The Technical Data Sheets are intended for use as standard templates, which will be completed and inserted into the Project Specification documents, so as to detail the project and product specific requirements for each Assembly as a whole, and for its constituent functional units.

Project specific configuration of the Technical Data Sheets will take the form of a 'YES' 'NO', insertion of a value or , together with the provision of an associated Particular Specification clause, cross-reference, or stated requirement, etc., as appropriate. When compiling a Project Specification document, only those Technical Data Sheets applicable to the required functional units will be included.

One set of Technical Data Sheets will be prepared per Assembly, unless therein detailed otherwise. Individual Technical Data Sheets may be duplicated if applicable, in order to accommodate the extent of scheme specific information.

15.1.5 Control Philosophy

The Control Philosophy will detail the functionality of all control and automation systems

15.1.6 Cable Block Diagram

The cable block diagram is a schematic that shows how the components of the Assembly is connected to the equipment and motors that it controls. It also indicates starting method, cable and circuit breaker sizes.

15.1.7 Assembly general arrangement drawing

A proposed layout shall be provided for the Contractor as indication of the relevant size constraints for the Assembly. It shall also indicate the number of functional units (e.g. motor starters, feeders, etc.) that is required for the Assembly.

15.1.8 Building arrangement drawing

A drawing indicating the Switchgear-room layout shall be used for functional considerations of the Assembly design. This drawing could be provided under the Civil part of the project.

16. TESTING AND COMMISSIONING

16.1 General requirements for testing

- 16.1.1 On completion of manufacture, the Assembly shall be subjected to a factory acceptance test (FAT), comprising the Manufacturer's in-house tests, and the repeat tests witnessed by the Client and the Engineer.
- 16.1.2 Once the witnessed FAT has been carried out, signed off, and any remedial works have been completed and re-tested, the Assembly is ready for delivery to site. Once erected in position, the Assembly shall be subjected to a witnessed site acceptance test (SAT).
- 16.1.3 Once the SAT has been carried out and signed off, any remedial works shall be completed and re-tested. Plant installation and site cabling will then be carried out by others, and on its completion, witnessed commissioning shall commence.
- 16.1.4 The manufacturer shall allow for each test (apart from in-house tests) to be witnessed by both the Client and the Engineers simultaneously. An individual testing activity shall not be considered to have been completed until any results have been recorded, and it has been signed off by the Engineer.
- 16.1.5 The manufacturer shall provide the Client and Engineers with all reasonable facilities, including testing staff and test equipment, to carry out the inspections and tests, and to check the Assembly for compliance with all of the Client's requirements.
- 16.1.6 The manufacturer shall ensure that all testing is carried out in a safe manner, and shall protect those witnessing from danger; in accordance with the Occupational Health and Safety Act.
- 16.1.7 In order to demonstrate the functionality of each circuit, external devices shall be simulated in a representative manner. A small motor shall be used as a test load where motor starters incorporate power electronics. During development, software may be electronically verified away from the Assembly using a simulation / diagnostic package; notwithstanding this, control systems shall be witnessed tested with the software loaded into the programmable devices, and with simulation of the physical I/O devices.
- 16.1.8 Where the Assembly incorporates equipment requiring special testing facilities or procedures, the manufacturer shall ensure that appropriate resources are available; including where necessary, representatives from the equipment Manufacturer.

PROCEDURE FOR TESTING AND COMMISSIONING

Action	Action By	Documentation
<pre> graph TD DA[Design Assembly] --> C1{Check} C1 -- Revise --> DA C1 -- Approve --> M[Manufacturing] M --> IFAT[In-house FAT] IFAT -- Revise --> M IFAT --> FAT{FAT} FAT -- Revise --> IFAT FAT -- Approve --> DTS[Delivery to Site] DTS --> C2(()) C2 -- Revise --> DTS C2 --> SAT{SAT} SAT -- Revise --> C2 SAT -- Approve --> OMC[O&M Manual & COC] OMC -- Revise --> SAT OMC --> C3{Check} C3 -- Revise --> OMC C3 -- Approve --> FTC[Final Test & Commissioning] </pre>	Manufacturer/Contractor Engineer Manufacturer/Contractor Manufacturer/Contractor Manufacturer/Contractor/ Engineer/ Client (If required) Manufacturer/Contractor Manufacturer/Contractor /Engineer Contractor to provide to Engineer Engineer Contractor provides O&M Manuals Manufacturer/Contractor /Engineer/Client(If required)	SLD drawings, Assembly GA drawings In-house FAT document Final FAT document, Functional Specification SAT document Draft Copy of O&M manual COC 3 Copies of approved O&M manual Commissioning Test document

FAT: Factory Acceptance Test; O&M Manual: Operating & Maintenance Manual; SAT: Site Acceptance Test; COC: Certificate of Compliance

16.2 Factory acceptance tests (FATs)

- 16.2.1 The manufacturer shall perform his in-house works tests in accordance with the proposed FAT procedures, and shall satisfy himself as to the accuracy and quality of the manufactured Assembly in accordance with the accepted design. Once the in-house FAT has been carried out, signed off by the manufacturer, and any remedial works have been completed and re-tested, the tests shall be repeated and witnessed by the Client (if required) and the Engineer.
- 16.2.2 The in-house and the witnessed FATs shall check compliance with SANS 60439-1, and shall include the following:
- a) A thorough external and internal visual inspection.
 - b) Confirmation of adequate earthing.
 - c) Secondary injection testing of all protective circuits shall be carried out, except where discrete current transformers are used; in which case sufficient primary injection testing shall be carried out to prove the ratio and the polarity.
 - d) Meggar tests shall be performed across all main and distribution busbar joints.
 - e) All busbars shall be subjected to a single witnessed reduced voltage dielectric 'flash' test; the in-house test shall also be at a reduced voltage.
 - f) All power circuits shall be subjected to insulation resistance tests.
 - g) The operation of every mechanical device and interlock shall be verified.
 - h) All circuits and their functionality shall be tested as detailed in the Control Philosophy and MCC and Local Control Table.
 - i) Any other test necessary to verify satisfaction with the requirements of Table 7 of SANS 60439-1.
- 16.2.3 When testing the performance of any software, it shall be demonstrated using the hardware intended to be incorporated within the Assembly, and where this is not possible appropriate operator interfaces, programming units, and terminal units, etc. shall be provided. Where it is necessary to demonstrate an interface with a piece of unavailable equipment to be supplied by others, appropriate means to replicate that equipment and simulate the interface shall be provided.
- 16.2.4 The Engineer preserves the right to cancel and postpone tests if he finds that the Contractor has not made reasonably sure that the test will be successful. Any extra costs incurred shall be borne by the Contractor.

16.3 Site acceptance test (SAT)

- 16.3.1 All equipment and every circuit that was altered or disturbed subsequent to the completion of the FAT, or for shipping and site erection, shall be specifically re-tested for integrity and functionality.
- 16.3.2 During the SAT, all busbar joints that are re-tightened on site shall be subjected to a further Meggar test, and all busbars shall be subjected to a single witnessed full voltage dielectric 'flash' test.
- 16.3.3 The process functionality of each aspect of the control system and its operator interface shall be demonstrated, including the correct operation of all I/O and network links external to the Assembly or not otherwise tested during the FAT.
- 16.3.4 A COC shall be provided to the Engineer, before final Testing and Commissioning can start.



16.4 Commissioning and other tests

- 16.4.1 The manufacturer shall provide attendance during the commissioning of the Assembly, whereby the functionality of the Assembly and its control system and software shall be proven. During commissioning the manufacturer shall make such adjustments, software modifications, and circuit changes, as are deemed necessary to provide the level of plant functionality and performance specified by the Client. All such changes shall be immediately incorporated into the 'as installed and tested' documentation and the Operating and Maintenance Manual, by the Contractor.
- 16.4.2 The manufacturer shall provide an acceptance document, to detail and record the tests and their anticipated results, and the acceptance document shall have provision for recording and signing off the results.

17. DOCUMENTATION AND TRAINING

17.1 General

17.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

- a) the Client's name and contact details
- b) Client's project / scheme / contract reference title and numbers
- c) the Engineer's name and contact details
- d) Engineers reference numbers
- e) Contractor's works / contract / order references.

17.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

17.2 Drawings for Approval by the Engineer

17.2.1 The following documentation and drawings shall be submitted to the engineer prior to the procurement or manufacturing of Assemblies and related equipment:

- a) Cable block diagrams.
- b) General arrangement and elevation drawings, compartment door layouts, typical component mounting plate layouts, and foundation plans.
- c) Electrical schematic diagrams showing all equipment and components incorporated into the Assembly. Known circuitry outside of the Assembly and connected to it, shall be shown on all drawings. Drawings shall be cross-referenced using a grid / line reference system.
- d) Protective device grading for overcurrent, short circuit, and earth fault / leakage devices incorporated within the Assembly, together with a schedule of proposed settings that will ensure discrimination.
- e) PLC software and configuration documentation; including ladder logic diagrams and HMI display screens, etc. The documentation shall be complete and annotated with purpose, function, duty, cross-references, and descriptions, etc.; sufficient to guide an unfamiliar person through the operation of the software.

17.3 Testing Documentation and Reports

17.3.1 The FAT and SAT shall be according to BS EN 62381.

17.3.2 A factory acceptance test (FAT) document shall be provided to the Engineer prior to the witnessed FAT. This documentation shall show the manufacturer's in-house test procedures and results for all items of equipment, components, hardware, and software. The document shall show hardware checks, the software simulation procedures, and their combined functional testing.. It shall comprehensively and clearly show the test results of the in-house testing. The subsequent report of the FAT witnessed by the Engineer shall be appended to this documentation.

17.3.3 The Contractor shall provide his own testing report template to document the FAT witnessed by the Engineer. This shall be to the satisfaction of the Engineer.

17.3.4 A site acceptance test (SAT) document shall be produced, which shall detail all tests necessary to demonstrate the functionality of the Assembly following its final erection on site. This shall include details of tests and checks on all circuits disconnected for shipping, together with any equipment, components, wiring, or software altered or incorporated into the Assembly; following the completion of the witnessed FATs.

- 
- 17.3.5 All drawings, schedules, listings, and other design documentation for acceptance shall be supplied as a comprehensive and integrated package and collated into folders; unless otherwise agreed with the Engineer. Three copies of appropriate documentation shall be submitted on each occasion that agreement is sought.
- 17.3.6 A Certificate of Compliance (COC) shall be provided for all new Assemblies. For all refurbished Assemblies, a letter shall be provided listing all the repairs and stating that the Assemblies are still deemed to be reasonably safe.
- 17.3.7 The FAT, SAT, and COC shall each have been submitted and agreed with the Engineer, prior to the commencement of final testing and site commissioning.

17.4 Certificate of Compliance

- 17.4.1 A Certificate of Compliance (COC) shall be provided for all new Assemblies. For all refurbished Assemblies, a letter shall be provided listing all the repairs and stating that the Assemblies are still deemed to be safe.
- 17.4.2 The original COC shall go to the client's electrical representative.
- 17.4.3 A copy of the COC shall be included in the O&M Manual.

17.5 Operating and Maintenance Manual

- 17.5.1 One copy of the draft operating and maintenance manual and spare parts list shall be provided at an agreed date; in advance of the date of the start of the final testing and commissioning SATs, for acceptance by the Engineer. Three copies of the final editions shall be provided to the Engineer by an agreed date before successful completion of final testing and commissioning.
- 17.5.2 The Operating and Maintenance Manual shall be bound into a suite of hard-backed ring binders, and shall be provided with an index of all drawings pertinent to the Assembly. The index shall include each drawing's origin, number, issue, status, and the Client's drawing number (where issued by the Engineer).
- 17.5.3 The Operating and Maintenance Manual shall include the following:
- a) All design drawings and documentation relating to the Assembly; as delivered and tested.
 - b) 'As installed and tested' records showing verification against stated design and installation criteria, including a schedule of all the final settings for all user adjustable equipment and components, and copies of all documentation presented and completed during the FATs, the SATs, and any other specified tests on completion.
 - c) Schedules of plant and equipment for each compartment / circuit; including a listing of the applicable standards, manufacturer, settings, type number, re-order code, etc., for each item of equipment and component included within the Assembly.
 - d) Manufacturers' contact details, technical information sheets for all items of equipment and components included within the Assembly. Manufacturers' catalogues may be provided subject to clear identification of the relevant components. All individual manufacturers' equipment / component test certificates and certificates of conformity, shall be included.
 - e) Inspection, testing, and maintenance recommendations, including detailed and specific operation, maintenance, and diagnostic data, and safe isolation information suitable for use by maintenance personnel, shall be provided for all equipment, components, and systems incorporated into the Assembly.
 - f) Schedule of spares provided with the Assembly, including manufacturer, description, part number, order code, and quantity.

- 17.5.4 The Operating and Maintenance Manual shall include detailed descriptions for use by the Client, on how the controlled plant and its management systems are intended to operate and be operated; under both manual and automatic control. Clear and detailed descriptions for each element of the Assembly shall be provided; and shall include system objectives, controlled plant start-up and shut-down procedures, automatic control, manual intervention, primary and secondary control routines, plant selection including duty and standby options, local and remote selections, operational and safety constraints, status information, alarms and control interfaces with control systems, fault routines, etc.
- 17.5.5 The Operating and Maintenance Manual shall include 'as-installed and tested' information on both the hardware and software for each programmable device incorporated within the Assembly, including:
- a) Overview of system operation in relation to the controlled plant.
 - b) System configuration.
 - c) Manufacturers' literature on operation, maintenance and testing of hardware and ancillaries, programming instructions, and diagnostics.
 - d) Hard copy program; with listings fully documented.
 - e) Listing of the final settings of all process dependent variables.
 - f) Permanent back-up copies, licensed in the name of the Client, shall be provided for all software, including operating programmes, application programs, and configuration software for all configurable devices.
- 17.5.6 Any interconnecting leads, protocol conversion modules, connectors, etc. necessary to connect and communicate with each programmable / configurable device to a standard portable Notebook.
- 17.5.7 Manual format shall be A4 size on the filing side which shall be vertical with 20 mm margin for filing.

17.6 Training

17.6.1 General

- a) The LV switchgear and Control Gear training shall form part of the overall training programme.
- b) The Contractor shall conduct training courses for designated personnel in the maintenance and operation of the Assemblies.
- c) The Assemblies shall be in a complete working order before training shall commence.
- d) A training schedule, together with the name and background of the person who will perform the training, shall be submitted to the Engineer for approval.
- e) Training and training manuals shall be based on the O&M Manuals.
- f) Training manuals shall be delivered for each trainee with two additional copies delivered for archival at the project site. The manuals shall include an agenda, defined objectives for each course.
- g) Where the Contractor presents portions of the course material by audio-visuals, copies of those audio-visuals shall be delivered to the Employer as part of the printed training manuals.
- h) The Employer reserves the right to videotape the training sessions for later use.
- i) The training shall include operator training and technical/maintenance training.
- j) During the installation phase, a person will be designated by the Employer to be closely involved with the installation and commissioning process. The intention is not to interfere with the Contractors' installation team, but to do observation in order to obtain the



maximum possible information regarding the installation, to enable efficient maintenance to be undertaken by the Employer after final hand-over and expiring of the guarantee period.

17.6.2 Operations & Maintenance training sessions

- a) There shall be training sessions for the operation and maintenance of the Assemblies
- b) The program for the training shall include instruction for at least one day per Assembly (8 hours) instruction on-site.
- c) The program shall at a minimum cover the following:
 - i) General system overview
 - ii) Functional operation of the system i.e.:
 - System start-up and shut-down procedures
 - System access requirements
 - Alarms
 - Fault Finding
 - Backup Power Procedure (if applicable)
 - Incident Reporting
 - iii) Maintenance
 - Maintenance Schedule
 - Standard Maintenance Procedures
 - Spare Part Lists
- d) Upon completion of the course, the operators should be fully proficient in the system operation and have no unanswered questions regarding the system.



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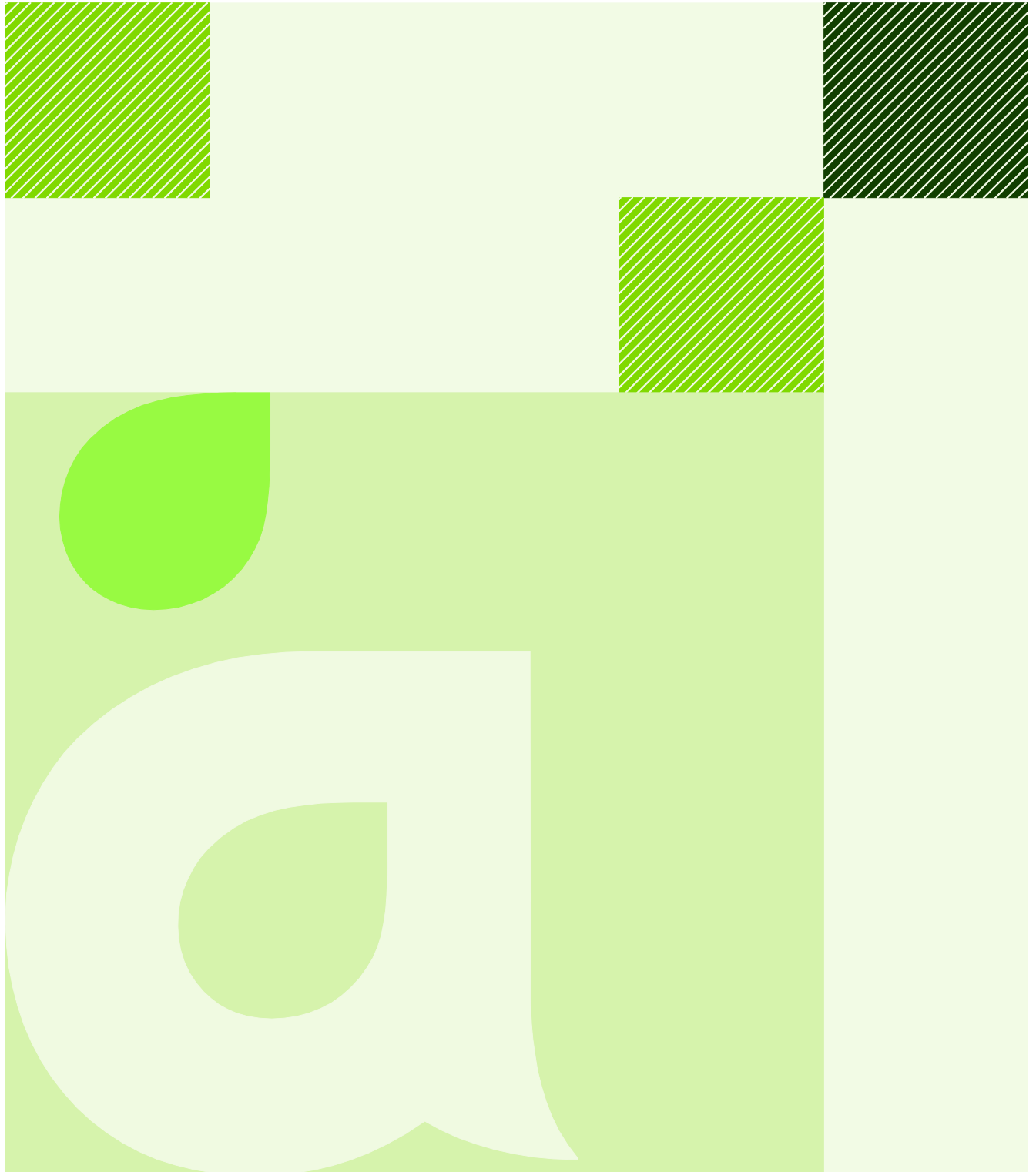
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LV Variable Frequency Converters

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1. SCOPE

1.1 Application

- 1.1.1 This standard specification (referred to hereafter as “this Specification”) covers a.c. variable frequency converters (VFCs) with rated output voltages up to 1000 V.
- 1.1.2 The VFCs covered by this Specification are for use with 50 Hz a.c. LV cage induction motors to form variable speed drives (VSDs).
- 1.1.3 VFCs are also referred to by certain manufacturers as “variable frequency drives” or “variable speed drives”. The IEC term for a variable speed drive as used in this Specification (i.e. a VFC in combination with a motor) is “adjustable speed drive system”.

1.2 General Requirements

- 1.2.1 VFCs shall be rated to suit the characteristics of the motor-driven loads specified in the Project Specification.
- 1.2.2 Unless otherwise specified in the Project Specification, VFCs shall be capable of only single-quadrant operation (i.e. motoring in one direction only).
- 1.2.3 Voltage-matching transformers shall not be used on the output to match VFC and motor voltage unless otherwise specified in the Project Specification.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification shall be read in conjunction with SANS 61800-2: Adjustable Speed Electrical Power Drive Systems: General Requirements - Rating Specifications for Low Voltage Adjustable Frequency A.C. Power Drive Systems.
- 2.1.2 This Specification contains standard amendments and additional requirements which shall be applied to the referenced statutory and national standards. Project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.

2.2 Statutory Requirements

The VFCs shall comply with the following:

- a) Occupational Health and Safety Act 85 of 1993 and Regulations
- b) SANS 10142-1 The Wiring of Premises Part 1: Low-voltage Installations

2.3 Reference Standards

- 2.3.1 The following national standards shall be complied with as applicable:

Table 1: Reference Standards

Standard Number	Description
SANS 60146-1-1	Semiconductor converters - General requirements and line commutated converters: Specifications of basic requirements.
SANS 60146-1-2	Semiconductor converters - General requirements and line commutated converters: Application guide.
SANS 60146-1-3	Semiconductor converters - General requirements and line commutated converters: Transformers and reactors.
SANS 60146-2	Semiconductor converters - Self-commutated converters including direct d.c. converters.
SANS 60204-1	Safety of machinery - Electrical equipment of machines: General requirements.
SANS 61378-1	Converter transformers - Transformers for industrial applications.
SANS 61800-2	Adjustable speed electrical power drive systems - General requirements: Rating specifications for low voltage adjustable frequency a.c. power drive systems.
SANS 61800-5-1	Adjustable speed electrical power drive systems - Safety requirements: Electrical, thermal and energy.
SANS 61800-5-3	Adjustable speed electrical power drive systems - EMC requirements and specific test methods.
SANS 61800-7-1	Adjustable speed electrical power drive systems - Generic interface and use of profiles for power drive systems.

- 2.3.2 The following Aurecon standards shall be complied with as applicable:

Table 2: Aurecon Standards

Standard Number	Description
SPE-EP-0020	Aurecon Engineering specification for dry type power transformers
SPE-EP-0023	Aurecon Engineering specification for distribution transformers



3. SERVICE CONDITIONS

3.1 Electrical Service Conditions

- 3.1.1 Normal service conditions shall be as stated in Clause 4.1.1 of SANS 61800-2 unless otherwise stated in the Project Specification.
- 3.1.2 The electrical characteristics of the supply network, including the source impedance and supply arrangement, will be as stated in the Project Specification.
- 3.1.3 Unusual electrical service conditions will be as stated in the Project Specifications.
- 3.1.4 VFC input current harmonics shall not exceed the limits stated in the Project Specification for individual harmonics and/or for total harmonic distortion.

3.2 Environmental Service Conditions

- 3.2.1 The climatic conditions shall be as stated in Clause 4.1.2.1 of SANS 61800-2 unless otherwise stated in the Project Specification.
- 3.2.2 Forced ventilation and/or air conditioners will be provided for rooms housing VFCs as specified in the Project Specification.
- 3.2.3 Unusual mechanical installation conditions (e.g. installation of VFCs on non-stationary equipment) will be as stated in the Project Specification.
- 3.2.4 Unusual environmental service conditions as defined in Clause 4.1.3 of SANS 61800-2 will be as stated in the Project specification.



4. TOPOLOGY OF DRIVE SYSTEM

4.1 Converter

- 4.1.1 VFCs shall be of the indirect converter type i.e. the power conversion from a fixed frequency and voltage a.c. input to a variable frequency and voltage a.c. output is performed with an intermediate d.c. link.
- 4.1.2 The line-side converter (rectifier) shall be a diode front end (DFE) or active front end (AFE) type as specified in the Project Specification or as required to achieve input current harmonic limits.
- 4.1.3 DFE converters shall be of the pulse number specified in the Project Specification or as required to achieve input current harmonic limits.
- 4.1.4 Bypass and/or redundancy arrangements shall be provided if and as specified in the Project Specification.

4.2 Converter Transformers

- 4.2.1 Converter transformers shall be provided on the line side of VFCs for voltage matching and/or phase shifting as specified in the Project Specification.
- 4.2.2 Converter transformers shall either be integral to the VFC or separate units as specified in the Project Specification.

4.3 Braking Arrangements

- 4.3.1 Unless otherwise specified in the Project Specification, the VFC shall not be provided with electrical braking.
- 4.3.2 Where electrical braking is required, it shall be regenerative and/or dynamic braking as specified in the Project Specification.



5. RATINGS

5.1 Input Ratings

- 5.1.1 The input voltage and frequency shall be as stated in the Project Specification.
- 5.1.2 The input currents (total rms, harmonic spectrum and auxiliary load) shall be provided in accordance with Clause 5.1.2 of SANS 61800-2.

5.2 Output Ratings

- 5.2.1 The operating speed range (minimum operating speed, base speed and maximum operating speed) shall be as specified in the Project Specification.
- 5.2.2 The output rating of a VFC shall be selected so that the associated motor can deliver rated continuous torque and any required overload capability.

5.3 Converter Transformer Rating

- 5.3.1 Converter transformers shall be selected and rated in accordance with Clause 5.4 and Annex C of SANS 61800-2.
- 5.3.2 Details shall be provided on the calculation of transformer ratings to suit the associated VFCs and loads.

5.4 Efficiency and Losses

- 5.4.1 The VFC efficiency and losses shall be provided in accordance with Clause 5.3 of SANS 61800-2.
- 5.4.2 The efficiency and loss figures shall include all VFC components such as converter transformer, ac reactors, dc link components, input (harmonic) filters and output filters.
- 5.4.3 Details shall be provided on how voltage and current harmonics have been taken into account in determining the transformer losses. Guaranteed efficiency and losses shall include harmonic loading.

6. CONTROL PERFORMANCE REQUIREMENTS

6.1 Steady State and Dynamic Performance

- 6.1.1 Unless otherwise specified in the Project Specification, a VFC shall have open loop speed control with a steady state deviation band of $\pm 1\%$ to $\pm 2\%$.
- 6.1.2 For applications requiring improved steady state speed control, a VFC shall have speed control with indirect feedback and a steady state deviation band as specified in the Project specification.
- 6.1.3 For applications requiring very good dynamic speed control, a VFC shall have closed loop speed control with direct feedback and with steady state and dynamic performance as specified in the Project specification.

6.2 Process Control Interface

- 6.2.1 A password protected control panel shall be provided for setting up, monitoring and troubleshooting VFC operations. An alphanumeric LCD display shall provide plain text messages in English. A membrane keypad shall be provided for menu navigation, item selection and data entry. The control panel shall be mounted in the front door of the enclosure (MCC or free-standing cabinet) housing the VFC, except for small VFCs which are mounted at a height where the LCD display can conveniently be viewed through a window in the enclosure's door.
- 6.2.2 The LCD display shall provide the following fault indication for the VFC as a minimum:
 - a) Overcurrent
 - b) Over-temperature
 - c) Loss of cooling air (where applicable)
 - d) Motor overload
 - e) Supply over/under voltage
 - f) Supply phase loss
 - g) Auxiliary power supply fault
 - h) Internal control system fault
 - i) Power circuit fault
- 6.2.3 In addition to the control panel, the following discrete controls and indicators shall be provided on the face of the enclosure's door:
 - a) Pushbuttons for start and stop operations
 - b) Emergency stop pushbutton
 - c) Selector switch for local/remote operation
 - d) Potentiometer for speed adjustment (but mounted inside the enclosure unless otherwise specified in the Project Specification)
 - e) Indicator lights for run, stop, fault and local operation indication
 - f) Display instruments for voltage, current and speed (unless otherwise specified in the Project Specification)
- 6.2.4 Isolated digital inputs and outputs shall be provided for:

- 
- a) Monitoring and control of VFC starters (if provided)
 - b) Protection signals from the converter transformer (if provided)
 - c) Shutdown of the VFC by field-mounted emergency stop pushbuttons
 - d) Starting/stopping of the VFC via the local control pushbuttons
- 6.2.5 Isolated analog (4-20 mA) inputs shall be provided for the following:
- a) Local speed adjustment via the local speed reference potentiometer
 - b) Monitoring of the three winding temperatures of the drive motor
- 6.2.6 The VFC shall provide a communication link via serial, parallel, network or fieldbus interface to a control system such as a programmable logic controller (PLC), motion control or drive control system. Preference will be given to VFCs that offer control interfaces and communications links with generic mappings to the various industry standard communications protocols and power drive system profiles as defined in SANS 61800-7 and Tenderers shall submit details in this regard with their offer.
- 6.2.7 When stated in the Project Specification, the VFC shall support one or more of the following industry standard communications interfaces and protocols:
- a) CANopen
 - b) EtherCAT
 - c) Ethernet
 - d) Powerlink
 - e) DeviceNet
 - f) ControlNet
 - g) EtherNet/IP
 - h) PROFIBUS
 - i) PROFINET
 - j) SERCOS
- 6.2.8 The VFC communications link shall provide access to the power drive system's selected profile to suit the application called for in the Project Specification. The minimum PDS profiles that shall be supported are the following as defined in SANS 61800-7:
- a) Process Control
 - b) Motion Control
 - c) Drive Control
- 6.2.9 The data to be transferred between the control system and the power drive system via the communications link shall be specific to the application and shall be clearly documented in the control system functional design specification (FDS) to be drawn up by the Contractor. For process control applications the minimum data to be transferred and displayed on the HMI / SCADA shall be the following as defined in SANS 61800-7:
- a) A unique VFC identifier
 - b) State of operation
 - c) Values of selected inputs and outputs (as defined in the FDS)
 - d) VFC commands (when in remote control mode)
 - e) Behaviour of the VFC control algorithm (selected profile)



6.3 Special Control Features

- 6.3.1 VFCs shall have an automatic restart facility to automatically restart the VFCs after a power failure or an undervoltage trip that has reset, and to ramp up to the current speed setpoint.
- 6.3.2 VFCs shall have a flying restart facility for an automatic restart of a VFC with a rotating motor.
- 6.3.3 VFCs shall have a facility for setting ramp times for acceleration and deceleration if required.
- 6.3.4 When specified in the Project Specification, the VFC shall have a facility to use the kinetic energy of a high-inertia load to improve the VFC's supply voltage dip ride-through capability.
- 6.3.5 It shall be possible to enable/disable the various facilities.



7. CONVERTER TRANSFORMERS

7.1 General Requirements

- 7.1.1 Converter transformers shall comply with the referenced Aurecon transformer specifications for general requirements, and with the referenced SANS converter transformer specifications for requirements relating specifically to converter applications.
- 7.1.2 The transformers shall either be of the dry type or of the oil-immersed type as specified in the Project Specification.
- 7.1.3 Transformers shall be suitable for the electrical and environmental service conditions stated under Clauses 3.1 and 3.2 respectively unless otherwise specified in the Project Specification.
- 7.1.4 Transformers shall be suitable for the specified application, i.e. for use with the associated converter and for the required load duty.
- 7.1.5 Transformer windings shall be designed to withstand the voltage offsets and stresses caused by the associated converter. An electrostatic shield shall also be provided between the primary and secondary winding with a low inductance connection to earth.
- 7.1.6 Converter transformers are exposed to a higher than normal risk of short circuits on the converter side and shall hence be designed for compliance with SANS 60076-5 Power Transformers: Ability to Withstand Short Circuit. The ability of the transformers to withstand the thermal and dynamic effects of a short circuit shall be demonstrated by calculation and design and manufacture considerations. Alternatively, certificates for type tests which include this special test on similar transformers may be submitted.

8. CONVERTERS

8.1 Enclosure

- 8.1.1 Converters shall be supplied in one of the following forms as specified in the Project Specification:
- a) Packaged units for installation inside LV Assemblies or for wall mounting
 - b) Chassis units for installation inside LV Assemblies
 - c) Free-standing cabinet units
- 8.1.2 Packaged units and cabinet units shall have an IP21 rating unless otherwise specified in the Project Specification.
- 8.1.3 Free-standing cabinets shall be manufactured from mild steel, unless otherwise specified in the Project Specification, and shall be epoxy powder coated inside and outside. Sheet steel thickness shall be between 0,75 mm and 2 mm as appropriate to provide a robust construction. Door locks and hinges shall be stainless steel or die-cast aluminium.
- 8.1.4 Cabinet enclosure door vents shall be fitted with front-mounted filters elements which can be replaced with the doors closed and the converter operational, without maintenance personnel being exposed to any hazards.
- 8.1.5 Enclosures shall be designed and constructed to provide the required EMC compatibility in accordance with SANS 61800-3.
- 8.1.6 Condensation shall be prevented from occurring inside enclosures through the provision of anti-condensation heaters and/or forced ventilation. The use of only anti-condensation paint will not be accepted.
- 8.1.7 LV Assemblies are covered by Engineering Standard SPE-EE-0010 "LV Switchgear and Controlgear Assemblies." and are separately specified in the Project Specification.
- 8.1.8 The printed circuit boards (PCBs) of VFCs installed at wastewater pump stations/treatment works shall be provided with a conformal coating to protect the electronic components against corrosive gases (specifically hydrogen sulphide). The same shall apply wherever the specified unusual environmental conditions include exposure of the VFCs to corrosive gases, chemically active dust and moisture.

8.2 Voltage Isolation and Safety Interlocks

- 8.2.1 Control circuits, components and power supplies shall be safely accessible for testing purposes without exposure to dangerous voltages with the converter operational.
- 8.2.2 A mechanical interlock system shall be provided to ensure that none of the power cabinets can be opened before the main switch-disconnector has been opened, DC link capacitors (in VSI converters) have been discharged, and the main earthing switch (if provided) has been closed.
- 8.2.3 The interlock system shall also ensure that the main power supply to the converter cannot be turned on unless the doors of the cabinet are closed and the main earthing switch (if provided) has been opened.



8.3 Cooling System

- 8.3.1 A forced-ventilation system and/or air conditioning will be provided for rooms housing VFCs as described in the Project Specification.
- 8.3.2 Packaged unit converters shall be equipped with integral cooling fans, and cabinets shall be equipped with fans which can be easily replaced on site. If required, provision shall be made to duct the outlet air from a converter cabinet to the outside of the building housing it.
- 8.3.3 Converters shall be fitted with temperature sensors to monitor the operation of the integral cooling system and initiate an alarm and protection trip.

8.4 Maintenance-Related Requirements

- 8.4.1 Converters shall be of modular design to provide for ease and speed of maintenance. All power components in the rectifier and inverter sections shall be easily accessible to allow components to be changed easily and quickly.
- 8.4.2 Faulty power switch components shall preferably be replaceable without removal of an entire converter module. Should this not be possible, Tenderers shall explain what the repair procedure involves and state the mean time to repair for components and modules.
- 8.4.3 Tenderers shall state the expected life of the offered converters and shall guarantee the availability of spares for that time.
- 8.4.4 The converters shall have software that performs a self-diagnosis of control hardware to facilitate fault finding.



9. MOTORS

9.1 General

- 9.1.1 Motors associated with VFCs covered by this standard specification are covered by Engineering Standard SPE-EE-0025 – “LV Electric Motors” and are separately dealt with in the Project Specification.
- 9.1.2 The above-mentioned standard specification requires that, for converter-fed motors, the Contractor shall arrange that the motor manufacturer checks the voltage stress withstand capability of the motor windings against the converter supplier's specification. To ensure that no service lifetime reduction of the motor insulation occurs, the actual stress due to converter operation shall be lower than the repetitive voltage stress withstand capability of the motor winding insulation system.
- 9.1.3 The required details of the VFC output shall be provided to the motor manufacturer for the above-mentioned checks to be made. Any other information relevant to the integration of the motor and the VFC shall also be provided to the motor manufacturer.



10. FILTERS AND REACTORS

10.1 Line-side Reactors and Filters

- 10.1.1 Line-side (VFC input) reactors shall be provided if required to achieve the input harmonic current limits specified in the Project Specification, or if required to increase the supply impedance for functional operation purposes.
- 10.1.2 If required, line-side reactors shall be provided for decoupling VFCs directly connected to the PCC or for parallel-connected VFCs.
- 10.1.3 Unless otherwise specified in the Project Specification, line-side reactors shall be installed inside the associated VFC enclosures.
- 10.1.4 Passive harmonic filters (HFs) shall be provided if the specified input harmonic current limits will be exceeded (without filters) and cannot be adequately reduced by line-side reactors alone. The Project Specification will state if HFs shall either be dedicated to VFCs or provided as common centralized filters.

10.2 Motor-side Reactors and Filters

- 10.2.1 Motor-side (VFC output) reactors shall be provided if required to allow the planned lengths of motor supply cables, subject to the motor insulation voltage stress limits not being exceeded.
- 10.2.2 Should it be necessary to reduce motor insulation voltage stress and/or bearing currents to levels not achievable with the use of only reactors, then suitable filters (dv/dt, common mode or sinusoidal) shall be provided.
- 10.2.3 Unless otherwise specified in the Project Specification, motor-side reactors and filters shall be installed in or directly alongside the associated VFCs. Free-standing reactors/filters shall be installed in cabinets which match those of the associated VFCs.



11. EARTHING

11.1 Supply System Earthing

- 11.1.1 The LV supply system earthing arrangement (i.e. earthing of the LV supply transformer neutrals) and the earth fault current will be as specified in the Project Specification.
- 11.1.2 The VFC and associated equipment (e.g. switchgear/controlgear and input filters) shall be rated to withstand the prospective maximum earth fault current.

11.2 Equipment Earthing and Bonding

- 11.2.1 Equipment protective earthing and bonding for the VFC and associated equipment shall be provided in accordance with Engineering Standard SPE-EE-0020 – “MV & LV Earthing” and as specified in the Project Specification.
- 11.2.2 Functional earthing and bonding shall be provided in accordance with the VFC manufacturer's instructions.
- 11.2.3 Special earthing and bonding for EMC and bearing current elimination purposes shall be provided in accordance with the VFC manufacturer's instructions.

12. PROTECTION

12.1 Line-side Supply Protection

- 12.1.1 Line-side protection against short-circuits and earth faults will be provided for the VFC feeder cables (to wall-mounted or free-standing cabinet units) by means of circuit-breakers in the associated LV Assembly as stated in the Project Specification.
- 12.1.2 Line-side protection for a VFC itself shall be provided by means of semiconductor fuses or a circuit-breaker (for input currents over 800 A) installed at the VFC. Unless otherwise specified in the Project Specification, an input contactor and a switch-disconnector shall also be provided where fuse protection is provided.
- 12.1.3 Drive emergency stop pushbuttons shall be hardwired to immediately disconnect the VFC line-side supply protective devices (circuit-breaker or contactor) when operated.

12.2 Converter Transformer Protection

- 12.2.1 Converter transformer short-circuit and earth fault protection shall be provided by the VFC's feeder circuit-breaker, and overload protection shall be provided by the converter's line side protection device.
- 12.2.2 The thermal and Buchholz (where applicable) protection of the converter transformer shall be integrated with the overall VFC protection.

12.3 Converter Protection

- 12.3.1 Converter protection shall be provided against the following conditions/faults:
 - a) Overcurrent and overload
 - b) Undervoltage and overvoltage
 - c) Phase loss and unbalance
 - d) Earth fault
 - e) Over-temperature
 - f) DC link overvoltage and overcurrent
 - g) Over-temperature of DC link reactor (if installed)
- 12.3.2 Over-temperature protection of free-standing harmonic filters shall be integrated with the overall VFC protection.
- 12.3.3 The operation of drive emergency stop pushbuttons shall initiate an uncontrolled stop of the converter (Category 0 stop as per SANS 60204-1) in conjunction with the tripping of the line-side supply (refer 12.1.3).
- 12.3.4 Uncontrolled (Category 0) stops shall also be provided for all converter faults which require such a shutdown of the converter for protection purposes.



12.4 Motor Protection

12.4.1 The following motor protection functions shall be provided by the VFC and/or a dedicated motor protection relay:

- a) Short-circuit
- b) Start (max starting time)/Stall (motors > 55 kW)
- c) Earth fault
- d) Overload
- e) Number of starts (motors > 55 kW)
- f) Loss of phase
- g) Unbalance (motors > 55 kW)
- h) Loss of load/undercurrent (delayed)
- i) Thermal by means of thermistors (in motors < 150 kW)/RTDs (in motors ≥ 150 kW)



13. DRIVEN EQUIPMENT INTERFACE CONSIDERATIONS

13.1 Critical Speeds

VFCs shall be capable of being set to avoid running the associated drives at critical speeds identified by the driven equipment supplier. This shall be achieved through the use of “skip frequency” selections.

13.2 Torsion Analysis

Where a torsional analysis of the mechanical drive string is called for in the Project Specification or by the driven equipment supplier, relevant information shall be provided on the VFC as required.



14. INSTALLATION

14.1 General

- 14.1.1 VFCs and associated converter transformers shall be installed in the locations specified in the Project Specification, and Tenderers shall clearly state in their tenders if the proposed arrangement does not suit their offered equipment, especially with respect to cable trenches and space allowances.
- 14.1.2 Unless otherwise specified in the Project Specification, VFCs shall be installed over cable trenches to allow for cable entry from below. Supports shall be provided to bridge cable trenches at enclosure ends and joints as necessary.
- 14.1.3 Dimensioned drawings shall be provided for concrete plinths required for outdoor converter transformers.

15. TESTING AND COMMISSIONING

15.1 General

- 15.1.1 Individual testing of a VFC's input (converter) transformer and the converter itself shall be performed as specified in Clauses 15.2 and 15.3.
- 15.1.2 Associated motors shall be individually tested as dealt with in the separate specifications for motors, but specific requirements for drive system testing are dealt with in Clause 15.4.
- 15.1.3 Complete drive system tests shall be performed on site as specified in Clause 15.5.
- 15.1.4 Witnessed factory acceptance tests (FATs) shall be carried out if specified in the Project Specification. The test procedure with relevant acceptance criteria shall be submitted to the Engineer at least six weeks before the FATs are carried out. FATs shall be in addition to type and routine tests and do not replace those tests.
- 15.1.5 VFCs shall be set up, tested and commissioned by a specialist commissioning Engineer who is accredited by the VFC supplier and who has experience in testing and commissioning the specific VFCs provided.

15.2 Transformers

- 15.2.1 Converter transformers shall be tested in accordance with Clause 6 of SANS 61378-1.
- 15.2.2 Type test certificates shall be submitted for all types and sizes of converter transformers offered in tenders.
- 15.2.3 All converter transformers shall undergo routine testing after manufacture and test certificates shall be submitted.
- 15.2.4 If the overall variable speed drive system efficiency is determined with the use of the segregated loss method, then the transformer harmonic losses shall be taken into account.

15.3 Converters

- 15.3.1 Converters shall be type- and routine tested in accordance with Table 7 of SANS 61800-2. Special tests shall only be carried out if specified in the Project Specification.
- 15.3.2 Type test certificates shall be submitted for all models of converters offered in tenders.
- 15.3.3 All converters shall undergo routine testing after manufacture and test certificates shall be submitted.

15.4 Motors

- 15.4.1 The Contractor shall arrange for the VFC supplier to provide whatever VFC data is required by the variable speed drive motor supplier to determine harmonic losses in the motors.

15.5 Drive System

- 15.5.1 The following drive system tests shall be carried out on site in accordance with Clause 7.4 of SANS 61800-2:
 - a) Light load test to prove control system
 - b) Load test (which may alternatively be a factory test)

- 
- c) Line side current harmonic content
 - d) Power factor (as part of load test)
 - e) Checking of auxiliary devices
 - f) Checking of coordination of protective devices

15.5.2 The following drive system tests shall be carried out on site in accordance with Clause 7.4 of SANS 61800-2 if specified in the Project Specification:

- a) Load duty
- b) Allowable full load current versus speed
- c) Temperature rise
- d) Efficiency
- e) Current sharing
- f) Voltage division
- g) Shaft current – bearing insulation
- h) Audible noise
- i) Motor vibration
- j) EMC tests
- k) Harmonic content of CDM output
- l) Current limit and current loop
- m) Speed loop
- n) Torque pulsation
- o) Automatic restart

15.5.3 The overall drive system efficiency shall be determined using either the segregated loss method or a system full load test on site as specified in the Project Specification.

15.5.4 Where a system full load test is specified in the Project Specification, the efficiency shall be determined using the measurement of input and output power.

16. DOCUMENTATION AND TRAINING

16.1 General

16.1.1 All drawings and documentation shall be in English, and each item shall be identified with:

- a) Employer's name and contact details
- b) Employer's contract reference title and number
- c) Engineer's name and contact details
- d) Engineer's reference numbers
- e) Contractor's works / contract / order references.

16.1.2 Drawings submitted to the Engineer for review and/or approval as specified shall be A4 or A3 paper copies as appropriate.

16.2 Drawings for Review/Approval by the Engineer

16.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the manufacturing of the VFCs and associated converter transformers:

- a) General arrangement drawings, enclosure door layouts, typical component mounting layouts, and foundation plans.
- b) Electrical schematic diagrams showing all equipment and components incorporated into the VFC and connected to it.
- c) Converter transformer rating plate information.

16.3 Test Documents and Reports

16.3.1 A factory acceptance test (FAT) document shall be provided to the Engineer prior to the witnessed FAT. This document shall include the manufacturer's in-house test procedures and results for all items of equipment, components, hardware, and software. The document shall show hardware checks, the software simulation procedures, and their combined functional testing. The report on the FAT witnessed by the Engineer shall include this document.

16.3.2 The VFC supplier shall provide a test report documenting the FAT witnessed by the Engineer. The test procedure with relevant acceptance criteria shall be submitted to the Engineer for approval prior to the FAT being carried out.

16.3.3 A site acceptance test (SAT) document shall be produced to record the results of all site acceptance tests witnessed by the Engineer. This shall be in addition to the test report for all drive system tests carried out on site in accordance with Clause 15.5.

16.3.4 Type and routine test certificates shall be provided for the VFCs and associated converter transformers and switchgear/controlgear.

16.4 Operating and Maintenance Manual

16.4.1 A draft operating and maintenance manual shall be submitted to the Engineer for approval within the specified time before site acceptance testing and commissioning may commence. The final approved version shall be submitted in accordance with the Contract.

16.4.2 The Operating and Maintenance (O&M) Manual shall include the following:

- a) All design and manufacturing drawings and documentation relating to the VFC

- 
- b) All test certificates, test procedure records and test result reports for factory and site tests
 - c) A components list and product data sheets for all VFC major components
 - d) A spares list with parts' and suppliers' details
 - e) Operating instructions
 - f) Maintenance instructions and schedules
 - g) Protection setting records

16.5 Training

16.5.1 The following general requirements relating to training shall be met:

- a) The VFC supplier shall conduct training courses on site for the Employer's staff in the maintenance and operation of the VFCs. The number of training courses and staff to be trained shall be as specified in the Project Specification.
- b) The training shall cover both theoretical and practical aspects of operation and maintenance, and the VFCs shall therefore be in complete working order before training may commence.
- c) A training schedule, together with the name and background of the person who will perform the training, shall be submitted to the Engineer for approval.
- d) Training and training manuals shall be based on the O&M Manual.
- e) Training manuals shall be issued to each trainee with two additional copies delivered for archiving at the project site. The manuals shall include an agenda and defined objectives for each course.
- f) Where portions of the course are in the form of audio-visual presentations, copies of those audio-visual presentations on DVD shall be provided to the Employer and hard copies of the visuals shall be included in the printed training manuals.
- g) The Employer reserves the right to videotape the training sessions for later use.
- h) The training courses shall be split into training for operational staff and training for maintenance staff.
- i) Upon completion of the courses the trainees' knowledge shall be formally tested to prove that an acceptable level of competency has been achieved.



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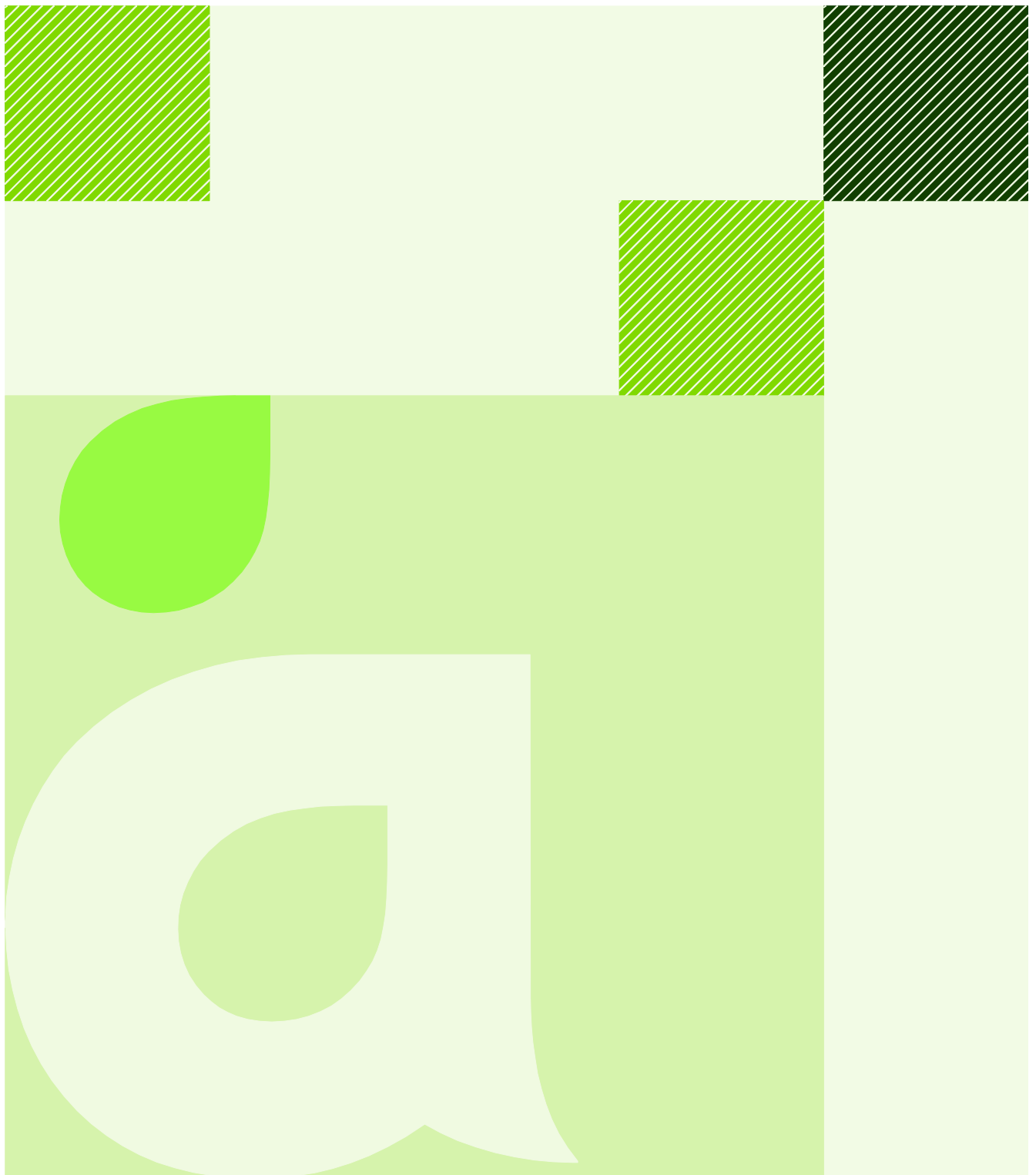
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1. SCOPE

1.1 Application

- 1.1.1 This Standard Specification covers the materials, components and installation requirements for earthing systems of industrial medium- and low voltage electrical installations.
- 1.1.2 General standard requirements are dealt with in this specification, and the project-specific requirements are dealt with in the Project Specification.
- 1.1.3 This standard specification covers protective earthing and bonding, but not functional earthing and bonding which shall be provided in accordance with the specifications of electrical and electronic equipment suppliers.
- 1.1.4 This standard specification does not cover electromagnetic compatibility (EMC) earthing and bonding, which shall be provided as specified in the Project Specification if required.
- 1.1.5 Whilst this specification covers earth termination systems for a building lightning protection system (LPS), it does not cover the LPS itself and surge protection for equipment.
- 1.1.6 The following does not fall within the scope of this standard specification:
 - a) The earthing of outdoor open-terminal MV substations.
 - b) The earthing of electronic systems and equipment.

1.2 General Requirements

- 1.2.1 The completed earthing systems shall incorporate all materials and components necessary to provide the required protective earthing and bonding.
- 1.2.2 All materials and components shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification contains standard amendments and requirements, which shall be applied to the referenced statutory and national standards. The project-specific requirements are provided in the Project Specification, which shall be read in conjunction with this Specification.
- 2.1.2 The design, construction, installation, inspection, testing and commissioning of the earthing systems shall comply with all relevant statutory regulations, and the latest editions (current at the time of tender) of all relevant South African National Standards.

2.2 Statutory Requirements

- 2.2.1 The earthing systems shall comply with the following:
- a) Occupational Health and Safety Act of 1993 and Regulations
 - b) SANS 10142-1 The Wiring of Premises Part 1: Low-voltage Installations
 - c) SANS 10142-2 The Wiring of Premises Part 2: Medium-voltage Installations

2.3 Reference Standards

- 2.3.1 The following national standards shall be complied with as applicable:

Table 1: Reference Standards

Standard Number	Description
SANS 1063	Earth rods, couplers and connections
SANS 1411-1	Materials of insulated electric cables and flexible cords - Part 1: Conductors
SANS 10198-3	Power cables up to 33 kV: Earthing systems - General provisions
SANS 10198-12	Power cables up to 33 kV: Installation of earthing system
SANS 10199	The design and installation of earth electrodes
SANS 10200	Neutral earthing in medium-voltage industrial power systems
SANS 10292	Earthing of low-voltage distribution systems
SANS 62305-3	Protection against lightning: Physical damage to structures and life hazard



3. EARTHING OF TRANSFORMER AND GENERATOR NEUTRALS

3.1 Distribution Transformers

- 3.1.1 The neutrals of distribution transformers shall be either solidly- (directly) or resistively earthed as specified in the Project Specification.
- 3.1.2 Unless otherwise specified in the Project Specification, the earthing connection shall be made with 70 mm² bare copper earth conductor to the installation's main earthing bar(s) or to dedicated combined MV and LV earth electrodes in the case of remotely installed transformers or mini-substations (refer Clauses 6.2 and 6.3).
- 3.1.3 Where artificial neutrals are required for transformers with delta-connected secondary windings, neutral electromagnetic couplers /neutral earthing compensators (NECs) shall be provided as specified in the Project Specification.
- 3.1.4 Where neutral earthing resistors (NERs) are required to limit earth fault current, they shall be provided as specified in the Project Specification, either as separate units or in combination with NECs (and referred to as NECRs).

3.2 Standby Generators

- 3.2.1 LV standby generators shall be earthed in accordance with SANS 10142-1: The Wiring of Premises Part 1: Low-voltage Installations unless otherwise specified in the Project Specification.
- 3.2.2 The neutrals of MV standby generators shall be resistively earthed with NERs dedicated to the individual generators unless otherwise specified in the Project Specification.
- 3.2.3 Unless otherwise specified in the Project Specification, the earthing connection shall be made with 70 mm² bare copper earth conductor via the installation's main earthing bar(s).

4. EARTH ELECTRODES

4.1 General

- 4.1.1 Earth electrodes shall be provided as specified in the Project Specification for power systems, electrical equipment and LPS earthing.
- 4.1.2 The earth electrodes shall be constructed in accordance with Sub-clauses 4.2 to 4.8 of this specification as relevant.
- 4.1.3 Earth electrodes shall be tested in accordance with Clause 9 of this specification and shall be extended as directed by the Engineer in writing if required to achieve a lower earth resistance.

4.2 Earth Grids

- 4.2.1 Earth grids for electrical equipment yards shall be constructed in the form of a large rectangular arrangement of conductors buried in trenches and divided by longitudinal and transverse conductors into a number of smaller rectangles having mesh dimensions as specified in the Project Specification.
- 4.2.2 The horizontal conductors shall be high-conductivity, annealed, stranded copper conductors with a cross-sectional area of 70 mm² unless otherwise specified in the Project Specification.
- 4.2.3 Where horizontal conductors cross each other they shall be joined by exothermic welding or oxy-acetylene brazing.
- 4.2.4 Horizontal conductors shall be buried directly in the ground at 500 mm below finished ground level (unless otherwise specified in the Project Specification), before any stone layer is put down, in 300 mm wide excavated trenches which shall be backfilled in well-compacted layers.
- 4.2.5 Supplementary earth rods shall be provided as specified in the Project Specification and shall comply with Clause 4.8 of the specification.

4.3 Ring and Foundation Earth Electrodes

- 4.3.1 A foundation earth electrode shall comprise a continuous length of bare copper earth conductor installed under the perimeter concrete foundation of a building, with the ends brought out to the main earthing bar to form a closed loop. The conductor shall be fixed to the top of the blinding layer just before the concrete foundation is poured to avoid theft of the conductor.
- 4.3.2 At each corner of the building a 2 m conductor tail shall be exothermically welded to the foundation earth electrode and buried in an accessible location to allow the electrode to be extended if required.
- 4.3.3 Supplementary earth rods shall be provided as specified in the Project Specification and shall comply with Clause 4.8 of the specification.
- 4.3.4 A ring earth electrode shall be similar to a foundation earth electrode, except that it shall be external to the structure and in contact with soil for at least 80 % of its total length. Unless otherwise specified in the Project Specification, the ring earth electrode shall be installed 500 mm below finished ground level and 1000 mm from external walls. Ring earth electrodes shall only be provided in place of specified foundation earth electrodes with the Engineer's written approval.
- 4.3.5 Horizontal conductors shall be as specified for earth grids in Clause 4.2.2 of this specification.

4.4 Array of Rods

- 4.4.1 An array of rods interconnected with horizontal conductor in the form of a “T” shall be constructed with horizontal conductor lengths and rod quantities and lengths as specified in the Project Specification to achieve the required earth resistance.
- 4.4.2 The horizontal conductor shall comply with Clause 4.2.2 of this specification.
- 4.4.3 The earth rods shall comply with Clause 4.8 of this specification.
- 4.4.4 The horizontal conductor and the tops of the earth rods shall be 500 mm below finished ground level.

4.5 Trench Electrodes (Cable-route Earth Electrodes)

- 4.5.1 Trench earth electrodes shall comprise buried horizontal conductor and supplementary earth rods installed in a linear arrangement in MV/LV cable trenches.
- 4.5.2 The conductor lengths and rod quantities and lengths shall be as specified in the Project Specification to achieve the required earth resistance.
- 4.5.3 The horizontal conductor shall comply with Clause 4.2.2 of this specification.
- 4.5.4 The earth rods shall comply with Clause 4.8 of this specification.

4.6 Earth Termination Systems for Lightning Protection

- 4.6.1 Earth termination systems (ETs) for lightning protection systems (LPs) for structures shall be either Type A or Type B arrangements (defined in SANS 62305-3) as specified in the Project Specification.
- 4.6.2 Ring- and foundation earth electrodes as specified in Clause 4.3 of this specification meet the requirements for Type B arrangements and shall be provided where called for in the Project Specification.
- 4.6.3 Type A arrangements shall comprise horizontal and/or vertical electrodes (i.e. conductors and/or rods) installed outside the structure to be protected, connected to down conductors, and not forming a closed loop. The required arrangement for a particular structure shall be as specified in the Project Specification.

4.7 Earth Mats

- 4.7.1 Earth mats shall be provided as called for in the Project Specification where required to provide an extra protective measure to minimize the danger of exposure to high step or touch potentials for operators of outdoor electrical equipment.
- 4.7.2 Earth mats shall be constructed out of 70 mm² bare copper conductor in the form of a grid with outer dimension 1500 mm x 1500 mm and with longitudinal and transverse conductors spaced 100 mm apart. Crossovers shall be exothermically welded.
- 4.7.3 Earth mats shall be buried 500 mm below finished ground level.

4.8 Earth Rods

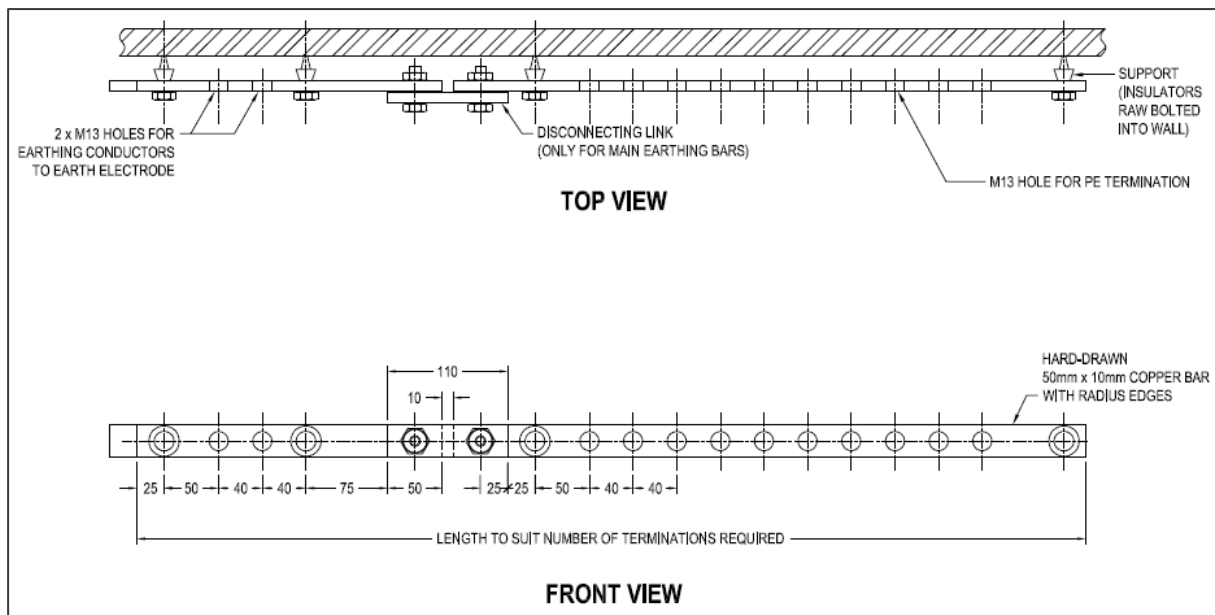
- 4.8.1 Earth rods used for the earthing system shall be of the “A” grade and shall have a 250 micron copper jacket. Unless otherwise specified in the Project Specification, the rods shall comply with the following:

- 
- a) The earth rods shall be extendible, copper clad, high tensile steel (500 MPa) rods and shall bear the SABS mark of approval. They shall be at least 16mm in diameter and shall have hardened steel tips with driving caps.
 - b) Individual rods shall not have a length of more than 1.5 m.
 - c) Connections between individual rods shall be by screwed joints in accordance with one of the following:
 - i) The ends of the rods shall be externally threaded and be joined by a counter bored, threaded coupler designed to completely enclose the threaded section of the rod. The external threads shall be roll-formed with a minimum copper coating thickness of 0,05 mm at the root of the threads. Couplers shall be manufactured from high strength silicon or aluminium bronze; or
 - ii) The ends of the rods shall be internally threaded and joined by a screwed phosphor bronze dowel. A corrosion inhibiting paste shall be applied to the threads before assembly.
 - d) A single earth rod assembly shall be not more than 6 m long and the separation between adjacent earth rod positions shall be not less than 1,25 times the length of the longest earth rod assembly.
 - e) The absence of any buried services, down to the maximum driving depth, shall be established before rods are driven into the ground.

5. EARTHING BARS AND CONDUCTORS

5.1 Earthing Bars

- 5.1.1 A main earthing bar shall be provided in every MV switchroom or in the main LV switchroom for installations with an LV bulk electricity supply. Supplementary earthing bars shall be provided in other electrical rooms as specified in the Project Specification.
- 5.1.2 All earthing bars connected to earth electrodes shall have one disconnecting terminal to allow for testing of the associated earth electrodes and shall be constructed in accordance with Standard Drawing for Earthing Bar (Figure 1).
- 5.1.3 Unless otherwise specified in the Project Specification, earthing bars shall be mounted on the side walls of cable trenches in the positions indicated on the layout drawings.
- 5.1.4 The earthing bar arrangement shall be as per the following detail sketch:



5.2 Earthing-, Parallel Earthing-, and Earth Continuity Conductors

- 5.2.1 Earthing conductors shall be provided to link earthing bars to earth electrodes, except where the conductor ends of ring- and foundation earth electrodes are terminated at the earthing bars. Earthing conductors shall be bare 70 mm² annealed stranded copper conductors, unless otherwise specified in the Project Specification.
- 5.2.2 Parallel earthing conductors shall be provided as specified in the Project Specification to provide a low impedance connection between separate earthing arrangements. Unless otherwise specified, the conductors shall be laid along cable routes, and shall be bare 70 mm² annealed stranded copper conductors.
- 5.2.3 Earth continuity conductors (ECCs) shall be provided:
- With supply cables to MV switchgear and to LV Assemblies
 - To earth the exposed conductive parts of all electrical equipment in accordance with SANS 10142: The Wiring of Premises.

- 
- 5.2.4 ECCs for MV equipment shall be connected from the MV earthing bar and ECCs for LV equipment shall be connected from the earthing bars in the LV Assemblies from which the equipment receives supply.
- 5.2.5 ECCs shall be separate conductors or shall form part of the equipment supply cables as specified in the Project Specification. ECCs which does not form part of a cable shall be annealed copper stranded conductors of the specified cross-sectional area and shall be either bare or PVC-insulated as specified in the Project Specification.

6. EARTHING OF MV AND LV EQUIPMENT AND ELECTRICAL YARD FENCES

6.1 MV Switchgear

- 6.1.1 The earthing bars of MV switchgear shall be connected to the main earthing bar by means of two 70 mm² bare copper earth conductors, unless otherwise specified in the Project Specification. These protective earthing conductors shall be taken from opposite ends of the switchgear earthing bars.
- 6.1.2 For ring main units (RMUs) in mini-sub, the RMU and cable termination enclosure earthing bars shall be bonded to the mini-sub's MV earth bar and to each other in accordance with SANS 1874: Metal-enclosed ring main units.
- 6.1.3 For RMUs in outdoor steel kiosks, the steel enclosure shall be bonded to the RMU earth bar with 70 mm² bare copper earth conductor.

6.2 Distribution Transformers

- 6.2.1 Outdoor ground-mounted distribution transformers shall be provided with an equipotential earth electrode in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2).
- 6.2.2 Unless otherwise specified in the Project Specification, the transformer tank earthing terminal shall be separately connected to the closest indoor main earthing bar with a 70 mm² bare copper earth conductor.
- 6.2.3 Unless otherwise specified in the Project specification, remotely-installed transformers (i.e. which are not installed close to indoor main earthing bars) shall be provided with dedicated combined MV- and LV earth electrodes in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2).
- 6.2.4 Transformer LV neutrals shall be bonded to the earthing terminal in the LV terminal box.
- 6.2.5 Distribution transformers shall be earthed and bonded in accordance with the Standard Drawing for Distribution Transformer Earthing (Figure 2):

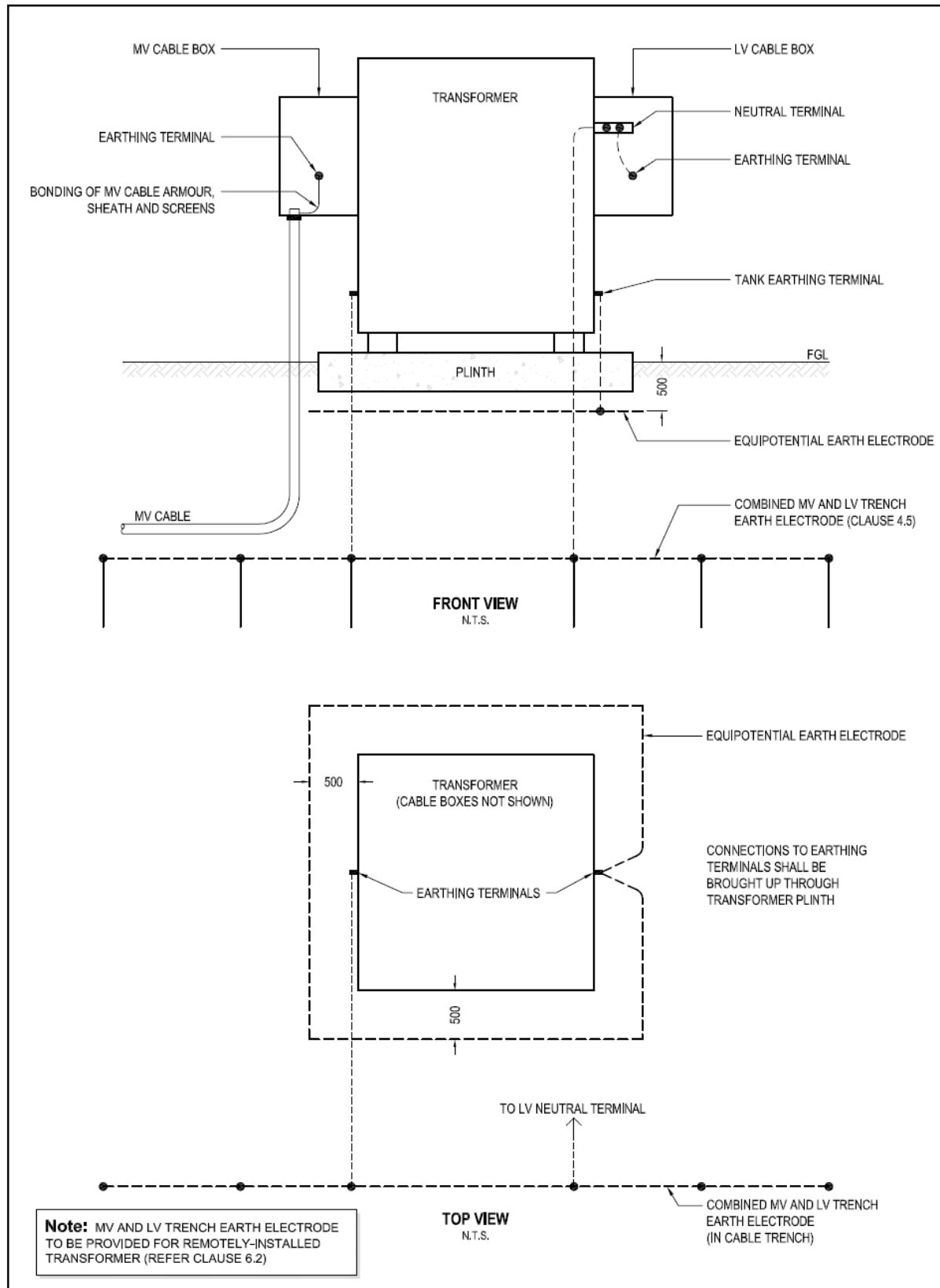
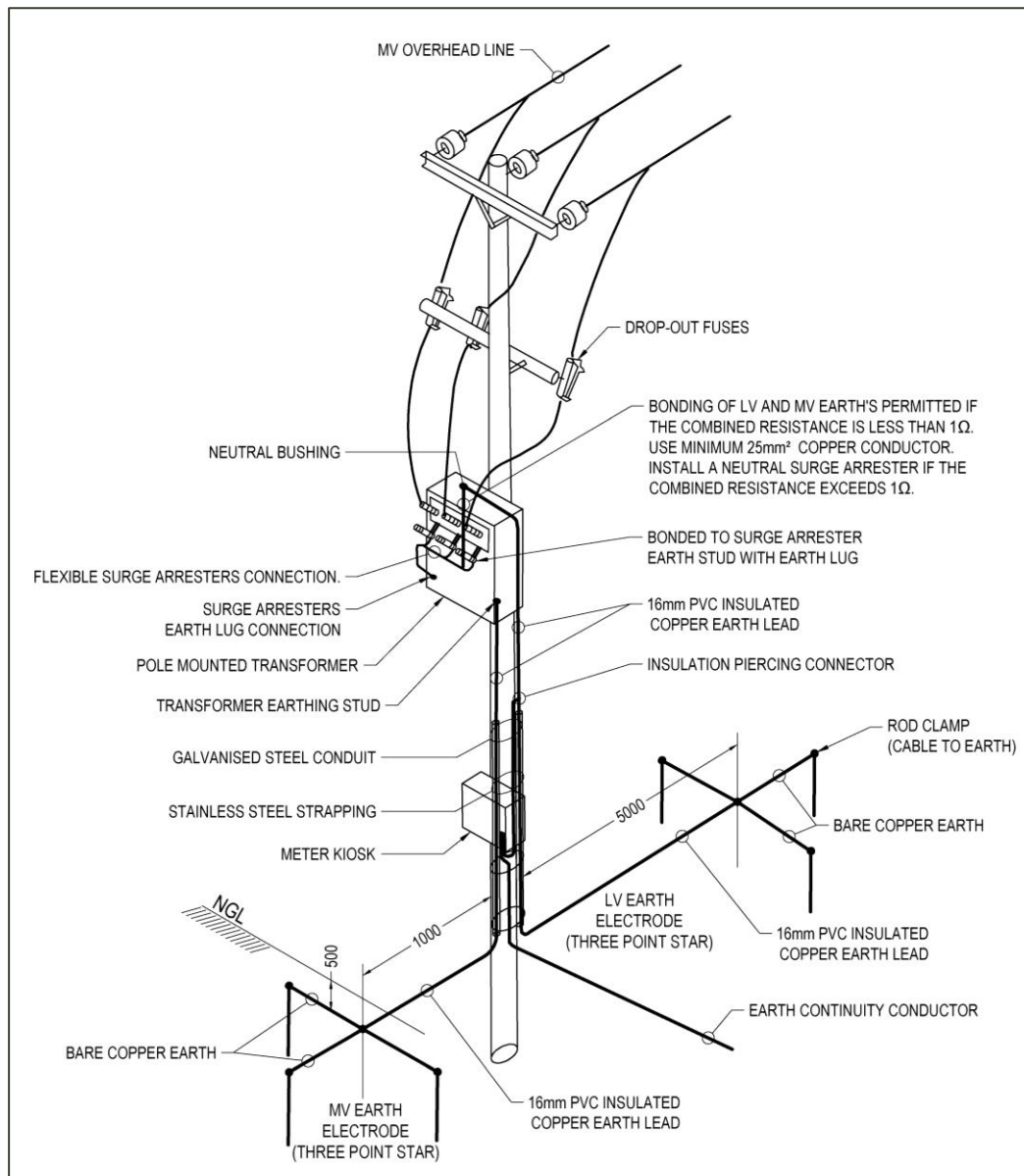


Figure 2: Distribution Transformer Earthing

6.2.6 Pole-mounted transformers shall be earthed in accordance with the Standard Drawing for Pole-Mounted Transformer Earthing (Figure 3):



NOTES

1. THE STEELWORK, TRANSFORMER TANK AND MV SURGE ARRESTERS ARE TO BE BONDED AND CONNECTED TO THE MV EARTH ELECTRODE.
2. THE TRANSFORMER NEUTRAL, LV SURGE ARRESTERS AND TRANSFORMER METERING BOX ARE TO BE BONDED AND CONNECTED TO THE LV EARTH ELECTRODE.
3. THE EARTHING CONTINUITY CONDUCTOR (ECC) SHOULD NOT BE SMALLER THAN HALF THE CROSS SECTIONAL AREA OF THE LARGEST CURRENT CARRYING CONDUCTOR OF THE SUPPLY CABLE.
4. A MINIMUM SEPARATION DISTANCE OF 5000mm IS TO BE MAINTAINED BETWEEN THE MV & LV EARTH ELECTRODES.
5. EARTH ELECTRODES SHALL BE COMBINED IF RESISTANCE IS LESS THAN OR EQUAL TO 1Ω.

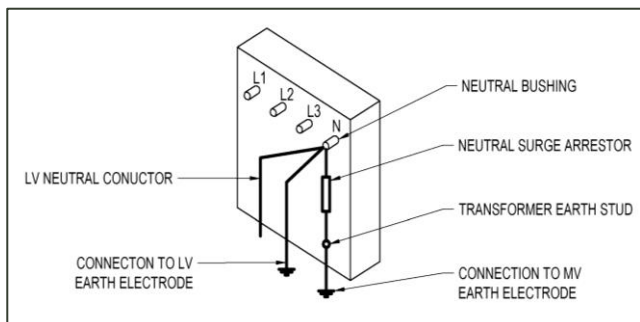


Figure 3: Earthing at MV/LV transformer pole mounted transformer



6.3 Miniature Substations (Mini-sub)

- 6.3.1 Mini-substations shall be provided with an equipotential earth electrode in accordance with Figure 4.
- 6.3.2 Unless otherwise specified in the Project Specification, the mini-sub MV earth bar shall be separately connected to the closest indoor main earthing bar with a 70 mm² bare copper earth conductor.
- 6.3.3 The internal earthing arrangement of mini-substations shall be in accordance with SANS 1029: Miniature Substations as applicable to combined MV- and LV earth electrodes.
- 6.3.4 Unless otherwise specified in the Project Specification, remotely-installed mini-substations (i.e. which are not installed close to indoor main earthing bars) shall be provided with a combined MV- and LV earth electrode, to which the mini-sub MV earth bar shall be connected, in accordance with Figure 4.

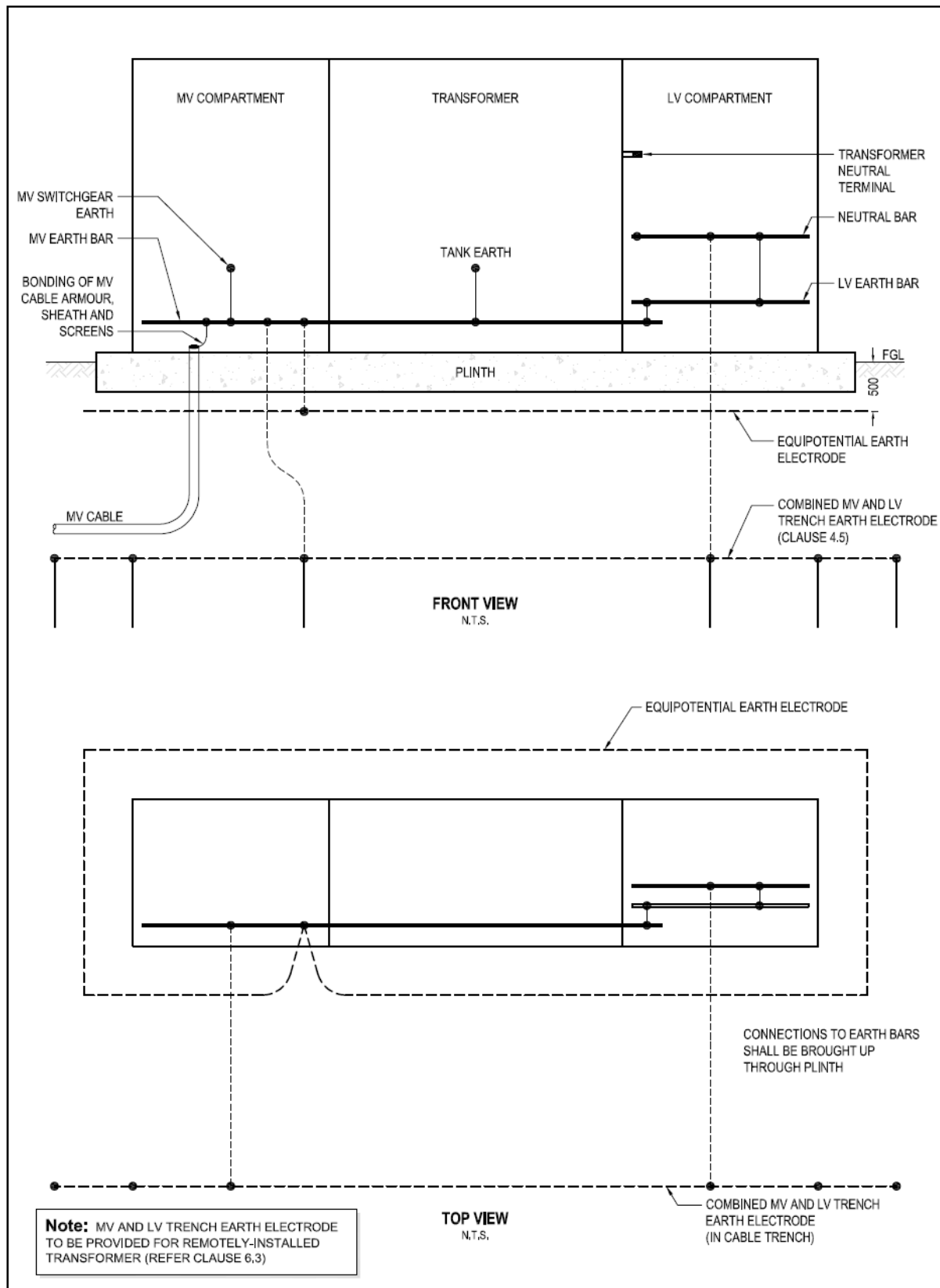


Figure 4: Mini Sub Earthing

6.4 Motors

- 6.4.1 Where the protective earth conductor forms part of the supply cable to an LV motor, it shall be connected to the earth terminal inside the motor terminal box.
- 6.4.2 Separate protective earthing conductors shall be connected to the external frame earth terminal of a motor and a jumper shall be provided from the frame terminal to the motor's terminal box. The jumper shall be crimped to the protective earth conductor and not separately bolted to the frame terminal.
- 6.4.3 Separate protective earthing conductors shall be PVC-insulated copper conductors with cross-sectional areas as specified in the Project Specification.
- 6.4.4 Earthing connections to converter-fed motors shall be in accordance with the Standard Drawing for Converter-Fed Motor Earthing.

6.5 PFC Capacitor Banks and Harmonic Filters

- 6.5.1 The capacitor casings and metal support frames of free-standing PFC capacitor banks shall be earthed in accordance with the supplier's installation instructions.
- 6.5.2 The support base/insulators of free-standing air-cored reactors shall be earthed in accordance with the supplier's installation instructions, with care being taken to not create closed loops within which currents can be induced.
- 6.5.3 Free-standing iron-cored reactors and filter resistors shall be earthed in accordance with the supplier's installation instructions.
- 6.5.4 Where equipment is installed indoors, the earthing connections shall be made with copper earthing continuity conductors to the main earthing bar.
- 6.5.5 Where the equipment is installed outdoors in a fenced yard, the earthing connections shall be made to the earth grid of the yard.

6.6 MV and LV Cables

- 6.6.1 The metal components of cables shall be earthed in accordance with the following standards:

Table 2: MV and LV Cable earthing standards

Standard Number	Description
SANS 10142-1	The Wiring of Premises Part 1: Low-voltage Installations
SANS 10198-9	Power Cables Up To 33 kV: Jointing and Termination of Extruded Solid Dielectric-Insulated Cables up to 3,3 kV
SANS 10198-10	Power Cables Up To 33 kV: Jointing and Termination of Paper-Insulated Cables
SANS 10198-11	Power Cables Up To 33 kV: Jointing and Termination of Screened Polymeric-Insulated Cables
SANS 10198-12	Power Cables Up To 33 kV: Installation of Earthing System

- 6.6.2 Unless otherwise specified in the Project Specification, metal sheaths, metal screens and armouring of single-core cables shall be earthed at both ends of the cables.
- 6.6.3 Unless otherwise specified in the Project Specification, metal sheaths, metal screens and armouring of single-core cables shall be earthed at both ends of the cables.

6.7 MV Surge Arresters

- 6.7.1 Surge arresters at MV overhead line supply points shall be earthed in accordance with the Standard Drawing for OHL Surge Arrester Earthing.

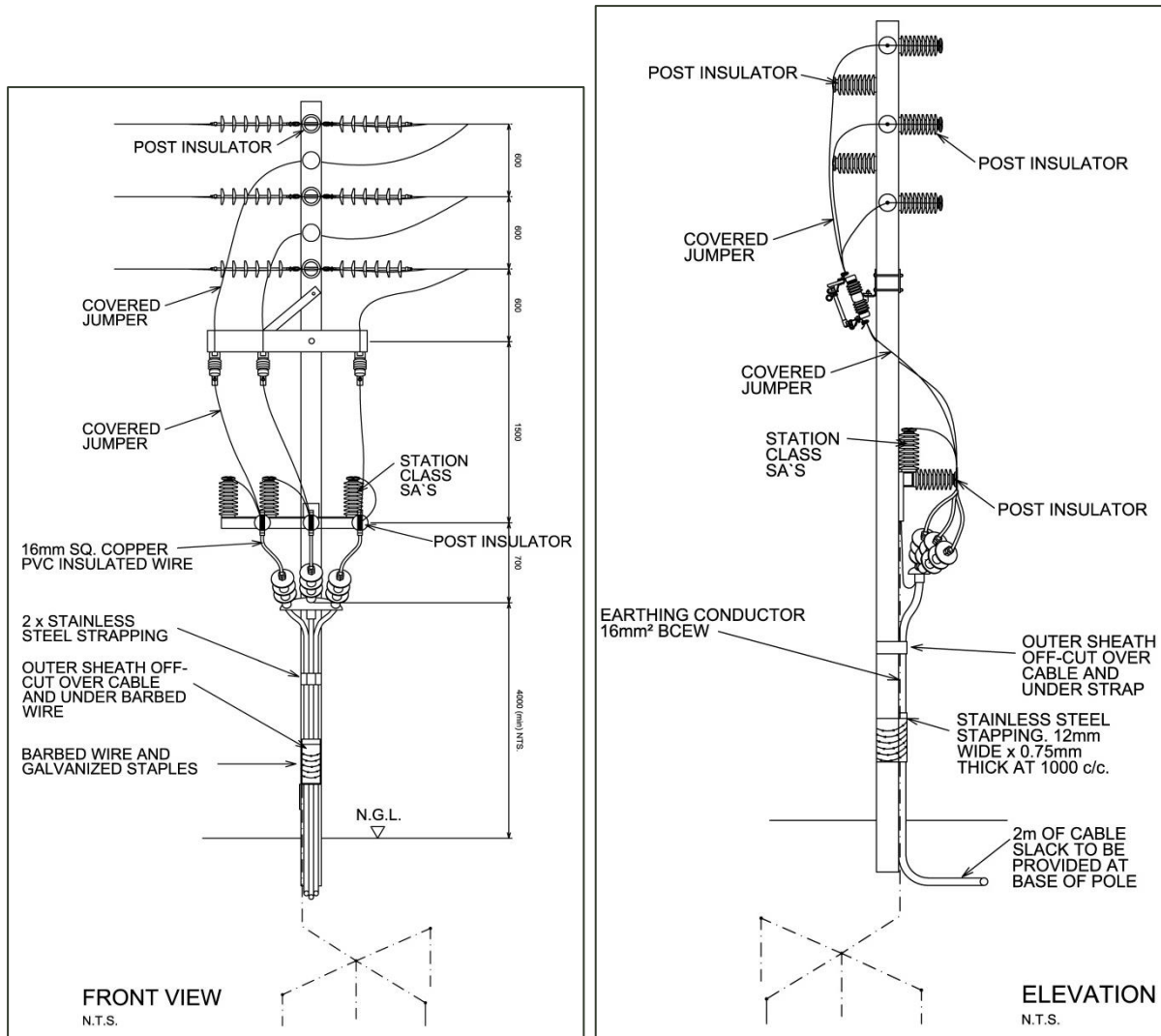


Figure 5: Earthing of MV Overhead Surge Arresters

6.8 Equipment Yard Fences

- 6.8.1 The enclosing fences of outdoor equipment yards for electrical equipment (switchgear, transformers, PFC capacitors, harmonic filters, etc.) shall be earthed in accordance with the Standard Drawing for Equipment Yard Fence Earthing.

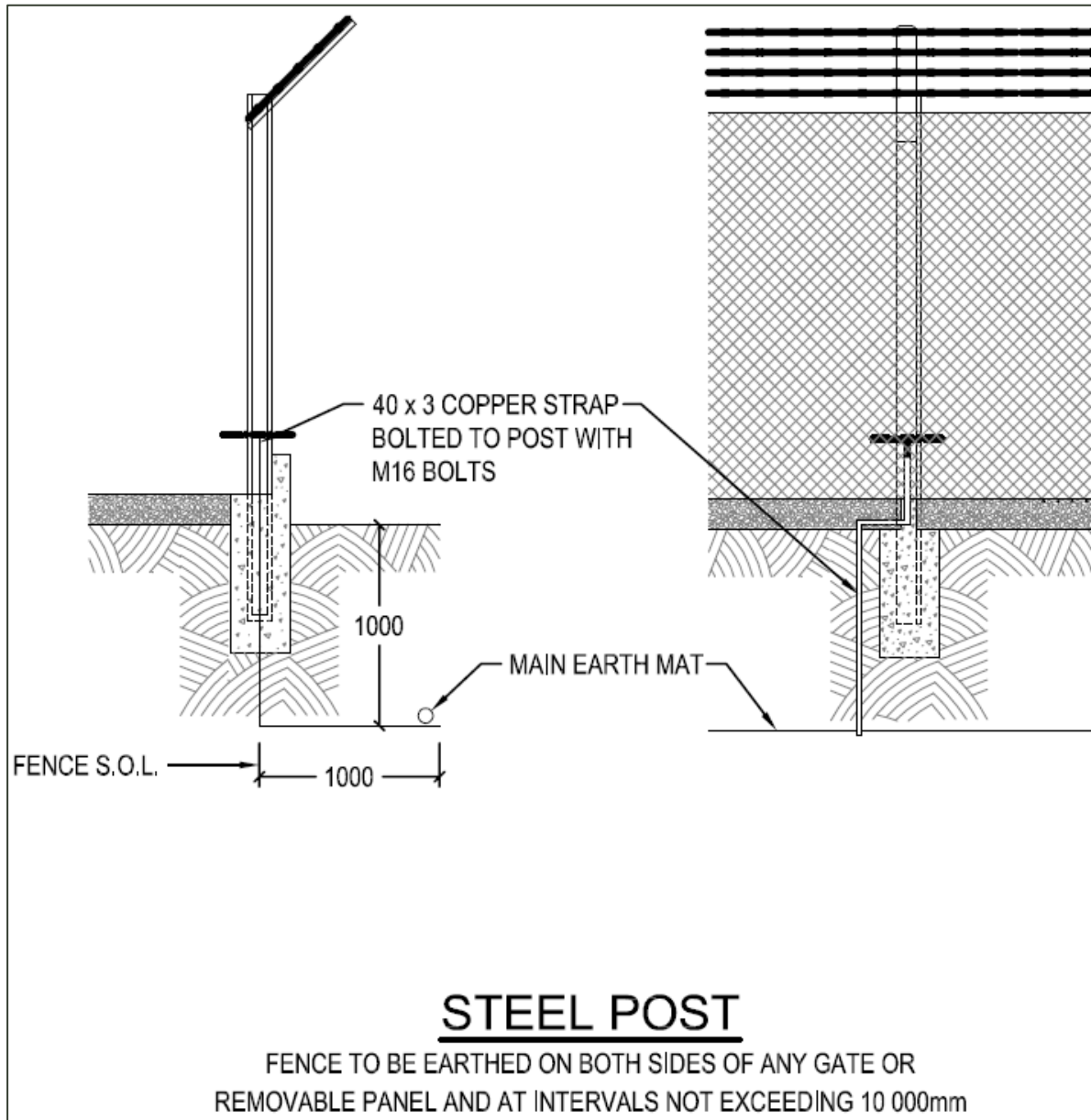
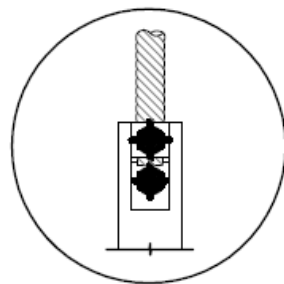
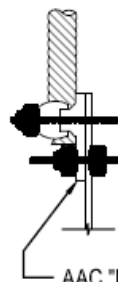


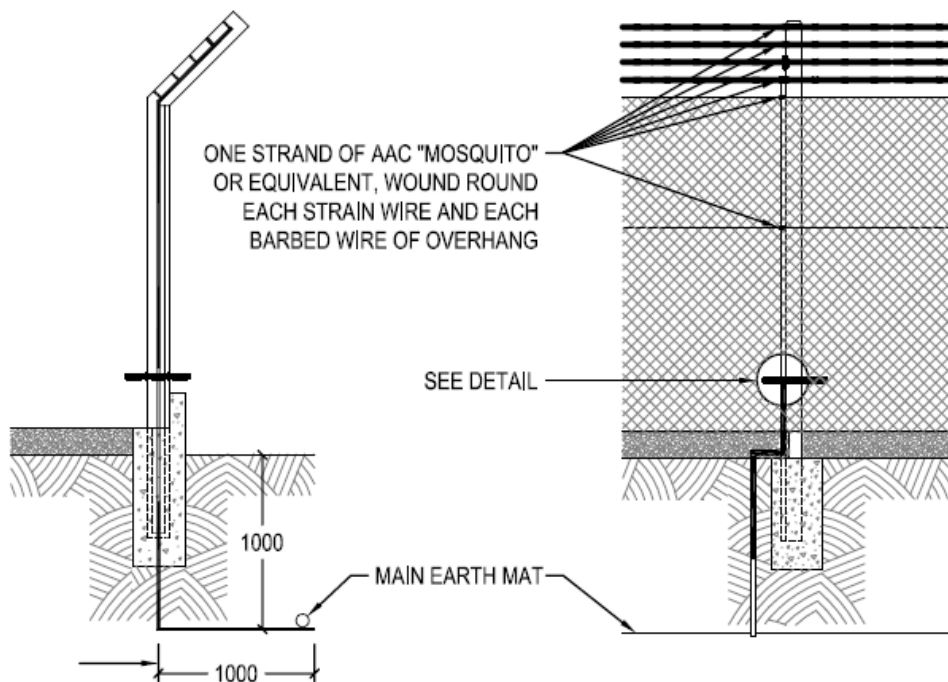
Figure 6: Earthing of Equipment Yard Fences



DETAIL



AAC "MOSQUITO" ALUMINIUM CONDUCTOR JOINED TO 40 x 3 COPPER STRAP BY "BURNDY" TYPE TINNED BRONZE TERMINAL LUG OR CRIMPED LUG WELL TAPED WITH "DENZO" (OR EQUIVALENT) TAPE



CONCRETE POSTS WITH ALUMINIUM WIRE FENCE

FENCE TO BE EARTHED ON BOTH SIDES OF ANY GATE OR REMOVABLE PANEL AND AT INTERVALS NOT EXCEEDING 10 000mm

6.9 LV Electrical Equipment

- 6.9.1 LV electrical equipment shall be earthed in accordance with SANS 10142-1: The Wiring of Premises Part 1: Low-voltage Installations.

7. EQUIPOTENTIAL BONDING

7.1 Main Equipotential Bonding

- 7.1.1 Main equipotential bonding shall be provided in accordance with SANS 10142-1 from the main earth bar to the following extraneous conductive parts of an installation:
- a) Hot and cold water systems
 - b) Antennas
 - c) Other services in conductive material
- 7.1.2 Main equipotential bonding conductors to the above shall be bare copper earth conductors with a cross-sectional areas as follows:
- a) Water systems: 0,5 x installation earthing conductor (6 mm² min to 25 mm² max)
 - b) Antennas: 2,5 mm²
 - c) Other services: 2,5 mm²

7.2 Supplementary Equipotential Bonding

- 7.2.1 Mandatory supplementary equipotential bonding shall be provided in accordance with SANS 10142-1.
- 7.2.2 Supplementary equipotential bonding shall be provided between exposed conductive parts of the installation where these parts are 2,5 m or less apart. The bonding conductor shall be bare copper earth conductor and shall not be smaller than the smaller of the two earth continuity conductors to the items of equipment.
- 7.2.3 Supplementary equipotential bonding shall be provided between exposed conductive parts and extraneous conductive parts where these are 2,5 m or less apart. The bonding conductor shall be bare copper earth conductor and shall be at least equal to the half the size of earth continuity conductor to the electrical item of equipment.
- 7.2.4 Bonding conductors shall be connected to equipotential bonding terminals on equipment/devices or, if these are not provided, shall be bolted to the equipment/devices to the approval of the Engineer.

7.3 Bonding of Wireways

- 7.3.1 A 70 mm² bare copper earth conductor shall be installed along each cable ladder/tray and each third section shall be bonded to the earth conductor with 35 mm² bare copper earth bonding conductors and purpose-made earth clips. At least one end, but where practicable both ends, of the earth conductor shall be connected to the main earthing bar.
- 7.3.2 Rigid metal conduiting shall be bonded in accordance with SANS 10142-1.



8. NECR AND NER

8.1 Neutral Electromagnetic Coupler/Resistor Combinations

- 8.1.1 Neutral electromagnetic couplers (NECs), also referred to as neutral earthing compensators, shall be provided as specified in the Project Specification to create artificial MV supply/transformer neutral points for earthing via a neutral earthing resistor (NER). The NEC and NER shall be a combined unit, referred to as an NECR.
- 8.1.2 NECRs shall comply with Aurecon Engineering Standard SPE-EP-0024: Neutral Electromagnetic Couplers (NEC) with NERs and Auxilliary Transformers.

8.2 Neutral Earthing Resistors

- 8.2.1 Standalone NERs shall be provided as specified in the Project Specification for resistive earthing of the neutrals of star-connected transformer secondary windings and MV generator windings.
- 8.2.2 NERs shall comply with Aurecon Engineering Standard SPE-EP-0024: Neutral Electromagnetic Couplers (NEC) with NERs and Auxilliary Transformers.

9. TESTING

9.1 Soil Resistivity Survey

- 9.1.1 A soil resistivity survey shall be carried out in accordance with SANS 10199 if specified in the Project Specification.
- 9.1.2 The Wenner method of measurement shall be followed unless soil depths of greater than 20 m are to be investigated.
- 9.1.3 The survey shall be carried out in the area where the earth electrode will be installed and readings shall be taken in at least two different directions. Unless earth rods are to be installed to greater depths than 12 m, measurements shall be taken with at least the following electrode spacings: 1/2/3/5/10/15 m.
- 9.1.4 The results of the survey shall be submitted to the Engineer in the form of a table showing soil resistivity in ohm.metres for the various depths of measurement, as well as in the form of a graph. If the graph shows a significant variation in soil resistivity with depth, then a two layer soil model shall be constructed.

9.2 Earth Electrode Resistance Measurement

- 9.2.1 The earth resistance of an earth electrode shall be measured in accordance with SANS 10199.
- 9.2.2 The resistance curve and the calculated earth electrode resistance shall be submitted to the Engineer who will issue a written instruction if it is necessary to extend the earth electrode to lower its resistance.

9.3 Earth Surface Potential Measurement

- 9.3.1 Where called for in the Project specification earth surface potential measurements shall be made by measuring touch- and step potential contact resistance at specified outdoor equipment.
- 9.3.2 The proposed measurement method shall be approved by the Engineer and resistance readings shall be submitted to the Engineer for the calculation of touch- and step potentials.

9.4 Earth Continuity and Bonding

- 9.4.1 Earth continuity and bonding tests shall be carried out in accordance with SANS 10142: The Wiring of Premises Parts 1 & 2.

10. DOCUMENTATION AND TRAINING

10.1 General

10.1.1 All Assembly drawings, documentation and reports shall be in English, and each item shall be identified with:

- a) Employer's name and contact details
- b) Employer's contract reference title and numbers
- c) Engineer's name and contact details
- d) Engineer's reference numbers
- e) Contractor's works / contract / order references
- f) Contractor's name and contact details

10.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

10.2 Drawings for Acceptance by the Engineer

10.2.1 Where alternative earthing arrangement designs to those specified are proposed by the Contractor, drawings shall be submitted to the Engineer for his acceptance before construction commences.

10.3 Testing Documentation and Reports

10.3.1 Test reports for soil resistivity tests shall contain the following:

- a) Methodology statement
- b) Measurement results in tabulated form
- c) Measurement results in graphic form
- d) Overlay of measured graph on master graph as per SANS 10199
- e) Calculated resistivity results for two layer model

10.3.2 Test reports for earth resistance tests shall contain the following:

- a) Methodology statement
- b) Measurement results in tabulated form
- c) Measurement results in graphic form
- d) Calculated resistance value for earth electrode under test

10.4 Operating and Maintenance Manual

10.4.1 As-built drawings and all test reports shall be included in the Operating and Maintenance Manual which must be provided under the Contract.



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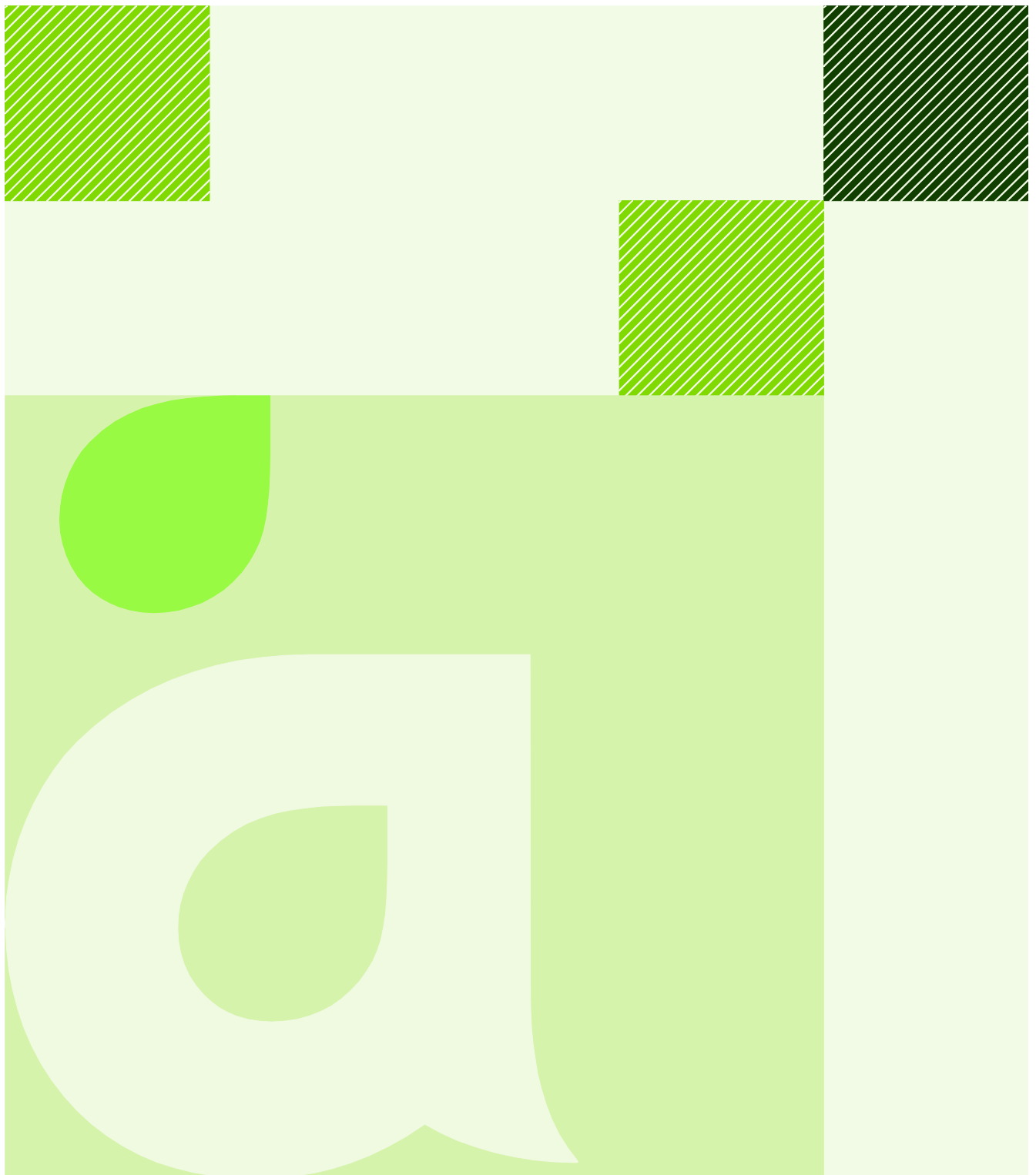
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Wiring and Outlets

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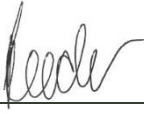
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1. SCOPE

1.1 Application

- 1.1.1 This document specifies the standard requirements for the design, installation, testing and commissioning of electrical installations operating on voltages up to 1 000 Volts AC / 1 500 Volts DC.
- 1.1.2 The primary intention of this specification is to ensure the provision of an electrical installation, which has been designed and constructed to ensure safe, reliable, operation and to facilitate safe inspection, testing and maintenance.
- 1.1.3 Note however that this specification only covers such installations (or sections of installations) that are covered by SANS 10142-1. Note also that certain provisions of this specification are inappropriate for direct application to installations where additional measures (such as earthing, intrinsic safe equipment, etc.) are required by SANS 10142-1 and SANS 10108 (i.e. medical and hazardous locations). For these types of installations, thorough reference must be made to the relevant statutory documentation.

1.2 Electrical System Characteristics

- 1.2.1 The design of the installation shall comply with SANS 10142-1.
- 1.2.2 The design of the installation shall consider the following supply characteristics:
 - a) Voltage, frequency and number of phases
 - b) Maximum prospective short circuit current (phase to phase and phase to neutral)
 - c) Type of system, e.g. TN-S, TN-C-S
 - d) Maximum earth loop impedance of the earth fault path external to the installation
 - e) Type and rating of the cut-out or switch device
 - f) Load capability of the supply source, particularly the effects on the supply voltage of the starting of new equipment and any fault contributions from new equipment
- 1.2.3 The installation protective devices shall be correctly co-ordinated within the installation and with respect to existing installations. Discrimination studies shall be performed to validate the co-ordination of the installation.
- 1.2.4 All equipment which requires operation or attendance by a person, or requires cleaning or maintenance in service, shall be constructed and installed to allow adequate and safe means of access and working space for such activities. Similarly, the positioning of equipment shall not impede access to, or working space at, non-electrical equipment and services for operation and maintenance activities.
- 1.2.5 The installation shall be suitable for access and use by electrically unskilled persons.
- 1.2.6 Where additions or alterations to an existing installation are to be performed, the rating and condition of existing equipment, including that associated with the supply, shall be verified to confirm its suitability to carry any additional load. The earthing and equipotential bonding arrangements shall also be verified. No addition or alteration shall have an adverse effect on the existing installation.

2. STANDARDS

2.1 Associated Documentation

- 2.1.1 This Specification identifies the Employer's standard modifications and requirements which shall be applied to the statutory and recognised standards. The detailed specification of the project or site-specific requirements will be found in the Particular Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Specification.
- 2.1.2 Any items not specifically detailed in this Specification, which are necessary to provide a safe and fully operational working system, shall be deemed to be included.
- 2.1.3 The Contractor shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the Installation.

2.2 Regulations, Specifications and Standards

- 2.2.1 The design, construction, inspection and testing of the installation shall comply with all relevant Statutory Regulations and Directives including:

- a) Occupational Health and Safety Act (Act 85 of 1993)
- b) Construction Regulations 2003 issued in terms of Section 43 of the Act
- c) Local Fire Regulations; and
- d) Regulations of the Local Supply Authority

and the latest editions (current at the time of Tender) of all relevant South African National Standards, as well as International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 32	Internal and/or external protective coatings for steel tubes - Specification for hot dip galvanized coatings applied in automatic plants
SANS 97	Electric cables – Impregnated paper insulated metal-sheathed cables for rated voltages 3,3/3,3kV to 19/22kV (excluding pressure assisted cables)
SANS 121	Hot dip galvanized coatings on fabricated iron and steel articles - Specifications and test methods
SANS 156	Moulded-case circuit-breakers
SANS 164	Two-pole and earthing-pin plugs and socket outlets
SANS 475	Luminaires for interior lighting, streetlighting and floodlighting - Performance requirements
SANS 767	Earth leakage protection unit
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1063	Earth rods, couplers and connections
SANS 1085	Wall outlet boxes for the enclosure of electrical accessories
SANS 1088	Luminaire entries and spigots
SANS 1091	National colour standards of Paint
SANS 1195	Busbars
SANS 1213	Mechanical cable glands
SANS 1239	Plugs, socket-outlets and couplers for industrial purposes
SANS 1266	Ballasts for discharge lamps (excluding tubular fluorescent lamps)

Standard Number	Description
SANS 1411	Materials of insulated electric cables and flexible cords
SANS 1431	Weldable structural steels
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1700	Fasteners
SANS 1777	Photoelectric control units for lighting
SANS 1783	Sawn softwood timber
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 2001	Construction Works
SANS 10155	Accuracy in buildings
SANS 10199	The design and installation of earth electrodes
SANS 10225	The design and construction of lighting masts
SANS 10177	Fire testing of materials, components and elements used in buildings Part 2: Fire resistance test for building elements
SANS 10142-1	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400	The application of the National Building Regulations
SANS 60269	Low-voltage fuses
SANS 60309	Plugs, socket-outlets and couplers for industrial purposes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60614-2	Conduits for electrical installations - Particular specification for conduits
SANS 60669	Switches for household and similar fixed-electrical installations
SANS 60947	Low-voltage switchgear and controlgear
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61010	Safety requirements for electrical equipment for measurement, control, and laboratory use
SANS 61048	Auxiliaries for lamps - Capacitors for use in tubular fluorescent and other discharge lamp circuits - General and safety requirements
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(U _m = 36 kV)
SANS 61643	Low-voltage surge protective devices
Other Standards	Description
ARP 035	Guidelines for the installation and maintenance of street lighting
BS 88	Specification of supplementary requirements for fuses of compact dimensions for use in 240 / 415 V industrial and commercial electric installations
IEC 157	Low voltage switchgear and control gear
IEC 408	Low voltage air-break switches, air-break disconnectors, air-break switch disconnectors and fuse combination units
IEC 12373	Aluminium and aluminium alloys. Anodizing. Method for specifying decorative and protective anodic oxidation coatings on aluminium
IEC 50086	Conduit systems for cable management
IEC 60898	Specification for circuit-breakers for overcurrent protection for household and similar installations

2.2.2 Standards are often tailored to the conditions of their country or origin (in terms of permissible voltages, expected ambient temperatures, etc.). Therefore, and unless normatively referenced to the contrary in a Standard of higher precedence, the decreasing order of precedence of Standards shall be:

- a) South African National Standards (SANS, VC, etc.)

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- b) South African Sectoral Standards and Specifications (NERSA, CKS, ARP, NRS, PIESA, etc.)
 - c) ISO Standards
 - d) IEC Standards
 - e) Harmonized British Standards (BS EN)
 - f) Other Harmonized European National (EN) Standards (CEN, CENELEC, ETSI)
 - g) Non-Harmonized British Standards (BS)
 - h) Other international standards

2.2.3 Where Standards of the same order are not in agreement with each other, the Standard with the most rigorous requirements shall apply.

2.2.4 The installation shall also comply with:

- a) This Specification, including all Technical Data Sheets; and
- b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

3. COMPONENTS AND EQUIPMENT

3.1 General

3.1.1 All equipment and components shall be suitable for their operating environment, particularly with respect to the following:

- a) The degree of ingress protection against dust and moisture (IP rating)
- b) The corrosion resistance of the materials of construction; and
- c) Mechanical properties (especially impact strength)

3.2 Power Outlets

3.2.1 Commercial Socket Outlets

- a) All socket outlets with switches shall fully comply with SANS 164 and SANS 60669-1.
- b) Units for flush mounting shall be suitable for a 100 x 100 x 50 mm deep flush wall box. Surface mounted patterns shall be housed in heavy pressed steel boxes. Shutters shall be included on the live and neutral socket holes.
- c) All socket outlets with switches shall be continuously rated at 16A and shall be suitable for operation on a 250V, 50 Hz, AC system.
- d) Cover plates shall have bevelled edges which overlap the box.
- e) Socket outlets and their cover plates must adhere to the following colour and earth pin convention:
 - i) White, with round earth pin, where outlets are protected by an earth leakage sensing device;
 - ii) Red, with shaved earth pin, where outlets are not protected by earth leakage sensing device (which outlets shall be referred to as "dedicated").

3.2.2 Industrial Socket Outlets

- a) Plugs, couplers and socket outlets shall conform to the requirements of SANS 1239.
- b) Where pilot connections are required, they shall disconnect before the main phase connectors disconnect.
- c) 3-Phase Socket Outlets
 - i) 400V socket outlets shall be five poled (three phases, one neutral and one earth), incorporating isolation mechanically interlocked with the plug.
 - ii) The equipment enclosures shall be at least IP 55 to SANS 60529.
 - iii) All welding plugs and socket outlets shall be 5 poled (3-phase, plus neutral, plus earth).
- d) Single Phase Outlets
 - i) 16 A, 250 V socket outlets shall be two pole and earth, incorporating isolation mechanically interlocked with the plug.

3.2.3 Local Isolators (Switch-disconnectors)

- a) Local isolators shall be selected from the following:
 - i) Isolator in accordance with SANS 60947-3, complete with additional late-make, early-break auxiliary contacts as required

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- ii) Plug and socket assembly to SANS 60309-1 and SANS 60309-2, incorporating isolation mechanically interlocked with the plug; or
 - iii) Plug and socket assembly to SANS 60309-1 incorporating a de-contactor arrangement or additional late-make early-break auxiliary contacts.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 General

- 4.1.1 Final positions of equipment shall be agreed with the Engineer on site, prior to installation.
- 4.1.2 All equipment shall be securely mounted using propriety (i.e. suited to and manufactured for such use) fixtures and fittings.
- 4.1.3 The method of equipment installation shall not adversely affect the function or structural integrity of the structure to which the equipment is attached.
- 4.1.4 Equipment terminals and covers shall be readily and safely accessible after installation.
- 4.1.5 The method of equipment installation shall not adversely affect the IP rating of the equipment.
- 4.1.6 No horizontal chasing shall be allowed into brick or concrete work.
- 4.1.7 It is the Contractor's responsibility to work closely together with the relevant parties responsible for the civil construction work to establish coordination in the installation program of components and conduits, as well as to establish a neat installation showing no indication of 'last minute changes'. Modification to existing structures shall be approved by the Engineer.
- 4.1.8 Framework and Brackets
 - a) Site-fabricated framework and brackets shall not be used.
 - b) Framework and brackets shall be positioned so as not to adversely affect the removal and replacement of equipment.
 - c) Where it is necessary to modify on site any pre-fabricated galvanised mild steel framework, the cut edges shall be dressed and treated immediately with an approved cold-galvanising paint to prevent corrosion.
- 4.1.9 Fasteners
 - a) Fasteners securing equipment to framework and brackets shall be independent of those securing framework and brackets to walls and floors.
 - b) No electroplated fasteners will be allowed. Only hot dipped galvanised or stainless steel fasteners will be allowed.
- 4.1.10 Positioning of Equipment
 - a) Equipment shall be positioned with due regard to the aesthetics of the installation.
 - b) Equipment (e.g. outlets, switches, distribution boards, etc.) shall be installed plumb. If an imaginary line is drawn from the vertical side of any such component, the deviation of such imaginary line from the vertical shall not exceed ± 5 mm for every 1 m increase in height, with a maximum deviation from the vertical of ± 10 mm.
 - c) The permissible deviation from the mounting heights indicated for equipment covered by this document shall be ± 10 mm, with a maximum of ± 5 mm deviation from the horizontal between adjacent outlets, isolators, luminaires, assemblies and / or switches.
 - d) Where a group comprises a number of items at different mounting heights, with not more than one item at any one height, then all items shall be sited on a common vertical centre line.

- e) Where a group comprises a number of items mounted at the same height, then all items shall be sited on a common horizontal centre line.
- f) Where a group comprises a number of different sized items they shall be arranged with the largest item at one end of the group and a progressive reduction in size of the remaining items.
- g) Where a group comprises a number of items at different mounting heights with more than one item at any height, then a common vertical centre line shall be established and the items arranged on, or symmetrically about, this centre line.
- h) Where a group comprises a number of items at the same mounting height with more than one item at the same position, then a common horizontal centre line shall be established and the items arranged on, or symmetrically about, this centre line.

4.1.11 Mounting height of Components

Mounting heights shall be as follows unless otherwise specified:

Table 2: Mounting height of components

Distribution boards	Top frame 2000 mm above finished floor level, except where the board may be accessible to infants, where then the bottom frame shall be 1200 mm above finished floor level
Switches	All security controls and light switches shall be horizontally aligned with door handles and other fixtures and fittings (other than socket outlets) between 900 mm and 1,2 m above the finished floor level
Socket outlets	See b)
Telephone outlets	Underside 500 mm above finished floor level

4.1.12 All distribution boards, switches and socket outlets shall be of the flush mounted type.

4.2 Installation of Socket Outlets

4.2.1 General

- a) The Contractor should only start installation of power outlets in the conduit outlets after plasterers and painters have completed their work in the vicinity of the outlet.
- b) Socket outlets shall be installed at the following heights above finished floor level, measured to the underside of the outlet:
 - i) 500 mm above finished floor level for general applications
 - ii) 500 mm above fixed ground level where they are to be installed outside buildings
 - iii) 1200 mm above finished floor level in kitchens
 - iv) 300 mm above counter tops

4.2.2 Connections to geysers

- a) Each geyser shall be connected to a separate circuit with a separate earth conductor.
- b) 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 length of conduit shall be installed between the isolator and the geyser.

4.2.3 Connections to heaters, fans, air conditioners and hand blowers

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- 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, which must then be of the type capable of being locked in the open position, shall be installed 1,5 m above floor level, and a sign indicating location of the isolator shall be fixed onto or next to the equipment that it switches. Flexible cords may be used for the final connection to the equipment, provided the cables are correctly current rated.
 - b) Where control units (for HVAC, BMS, etc.) are to be installed, the units shall be installed 1,5 m above the finished floor level.

4.3 Installation of Telecommunication Services and Accessories

4.3.1 Telephone distribution boards

- a) Telephone distribution boards are to be installed with their bottom frames 1 200 mm above finished floor level.
- b) All conduits and sleeves to telephone outlets or telephone sub-distribution boards in the buildings or elsewhere on the site, as well as the main incoming sleeves, shall terminate at the main telephone distribution board, as shown on the relevant drawing.

4.3.2 Separation of services

- a) Wireways provided for telecommunication or other related services shall under no circumstances be used for any other purpose.
- b) Power cables, conductors and accessories shall be installed at a minimum distance of 300 mm away from the routes reserved for telecommunication cables.
- c) Conduits and other channels shall be installed in such a way as to avoid telecommunication cables from crossing power cables.

4.4 Telecommunication outlets

- a) Telephone and / or data outlets in walls shall comprise of 100 x 100 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 fixed 500 mm above the finished floor level. The wall box shall be fitted with a white coloured blank cover plate.
- b) All outlet boxes shall align neatly with adjacent socket outlet wall boxes.
- c) Outlets in floors fitted with floor ducting shall be of the same type as the floor outlets for power socket outlets, and shall be provided in the same outlet box.
- d) Outlets in power skirting shall be provided at the positions indicated on the relevant drawing, and the Contractor need only provide a separate short length power skirting cover at these positions. The cover for the fixing of outlet shall not exceed 250 mm in length, and shall be secured in such a manner that adjacent cover plate sections can be removed without disturbing the telephone outlet.

5. WIREWAYS

5.1 Conduit

5.1.1 Plain-end metallic conduit and accessories

- a) Plain-end conduit shall be manufactured from mild steel having a minimum wall thickness of 0,9 mm and shall comply with SANS 60614.
- b) Galvanised conduits shall be hot-dipped on both the internal and external surfaces, in accordance with SANS 121.
- c) Epoxy powder-coated metal conduit may not be used in installations where bending of conduit will be required (unless prior approval of use has been granted by the Engineer).
- d) Bending and setting of plain-end conduit shall be undertaken using the correct bending apparatus as recommended by the manufacturer of the conduit. After the bending of galvanized conduit, cold galvanizing paint shall be applied.

5.1.2 PVC conduit and accessories

- a) PVC conduit shall comply with SANS 950 and shall bear the SABS mark.
- b) PVC conduit shall be constructed from rigid PVC. PVC conduit shall be white in colour and shall be non-flammable. The minimum softening temperature shall be 75 °C.
- c) All PVC conduit accessories shall be fully in accordance with SANS 950 and shall bear the SABS mark.

5.1.3 Flexible conduit

- a) Flexible steel conduit and adaptors shall comply with IEC 50086 where applicable.
- b) Flexible steel conduit shall be of a galvanised steel construction. It does not need to be waterproof, but shall be vermin proof and suitable for protection of cables against mechanical damage.
- c) In moist or damp areas, flexible steel conduit shall be of the plastic sheathed galvanised steel type.
- d) Flexible polypropylene tubing shall only be fastened to PVC conduit installations.

5.1.4 Conduit Accessories

- a) Earth clamps
 - i) 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 such that the clip can be firmly attached to the conduit without the need for any additional packing.
- b) Flush mounted wall boxes
 - i) 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.
 - ii) Flush mounted steel wall boxes shall be manufactured from heavy gauge sheet steel and shall be galvanised. All steel wall boxes shall comply with SANS 1085.
 - iii) The boxes shall be provided with the necessary mounting lugs to suite the units for which the box is intended and be provided with 20 mm knock-outs.
 - iv) Facilities shall be provided for the fixing of earth terminals to the box.

c) Round group-type circular boxes

- i) Steel round boxes shall be manufactured in accordance with SANS 1065 and shall be of the long spout pattern, constructed from either store enamelled jet black or galvanised steel, or from malleable cast iron.
- ii) PVC round boxes shall be manufactured in accordance with SANS 950 and of the same dimensions, but having web-reinforced spouts.
- iii) The two cover fixing holes of both steel and PVC boxes shall be diagonally opposite each other, and shall be drilled and tapped at 50 mm centres. 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.
- iv) 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.
- v) PVC round box covers shall be of PVC and shall be secured by means of brass screws at 50 mm centres.

d) Draw wires

- i) Draw wires for unused conduits shall either be galvanised steel wire or nylon, but shall have a minimum diameter of 2 mm.

5.1.5 Conduit Installation

a) General

- i) The conduit installation shall comply with par. 6.5 of SANS 10142-1.
- ii) Where the conduit installation is surface mounted, space-bar saddles must be used in order to provide an air gap between the conduit and mounting surface.
- iii) The conduit system shall be mechanically continuous, secure and rewirable.
- iv) All unused, screwed entries shall be fitted with a blanking plug. Female PVC bushes shall be fitted to all free ends.
- v) Conduits shall not be used to support the weight of fittings etc., except where specifically designed to do so. Conduit boxes supporting luminaires or accessory boxes shall be fixed to the fabric of the building independently of the conduit.
- vi) Sufficient conduit and drawing boxes shall be provided to facilitate cable installation and removal. In general, no more than 2 bends or off-sets or one coupling shall be permitted without a conduit box.
- vii) Steel conduit shall not be relied upon for earth continuity
- viii) All PVC conduits shall be installed in accordance with Appendix C, SANS 950.
- ix) Draw boxes should be as far as possible be placed out of sight and shall be indicated on the "as built" drawings.
- x) The edge of flush mounted outlet boxes shall not be deeper than 10 mm from the final surface. Where necessary, spacer springs shall be used under screws.
- xi) 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 plates.

b) Flexible conduit

- i) 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.
- ii) 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.
- iii) 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 construction 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.

c) Installation in concrete

- i) In order not to delay building operations, the electrical Contractor shall ensure that all conduits and accessories which are to be cast in concrete are placed in position in good time. The Contractor or his representative shall be in attendance when the concrete is cast.
- ii) Draw boxes, expansion joints and round ceiling boxes shall be installed where required and shall be neatly finished to match the finished slab and wall surfaces. Ceiling draw boxes shall be of the deep recessed 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.
- iii) Sharp bends and elbows for conduits of 32 mm diameter will not be allowed in concrete slabs.
- iv) 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 brass screws.
- v) 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.
- vi) 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.
- vii) 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. The gap between the sleeve and the conduit at the joint shall be sealed with TiC-TaC (Titanium Carbide / Tantalum Carbide) or equal sealing compound, to prevent the ingress of wet cement. The other end of the circuit conduit shall be secured to the draw box by means of a standard bushed adaptor for other PVC types. 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.

- viii) 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 Contractor shall ensure that conduits are not visible above the screed where the conduits leave the screed.
- ix) 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. Errors that occurred during the installation of the conduits, or any lost draw boxes or blocked conduits shall be reported to the Engineer immediately.
- x) Where it is necessary to cut or drill holes in the concrete structure, prior permission shall be obtained from the Engineer in writing.
- d) Installation in brickwork
 - i) Recessed conduits and accessories installed in brickwork shall be built-in. In order not to delay building operations the Contractor shall ensure that all conduits and accessories which are to be built-in are placed in position in good time.
 - ii) Any conduit draw boxes, outlet boxes, etc., which have been damaged, lost or omitted, shall immediately be reported to the Engineer.
- e) Surface and roof space installations
 - i) 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.
 - ii) Conduits shall be firmly secured by means of saddles and screws and in accordance with SANS 10142, par. 5.4.2(b). Conduits shall be secured within 150 mm before and after each 90° bend.
 - iii) Only approved plugging materials, such as fibre plugs or plastic plugs, etc., and round head 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.
- f) Chasing and builder's work
 - i) Except where the project involves upgrading existing facilities, all flush mounted conduits, accessories, switchboard trays, bonding trays etc., shall be built-in and no chasing shall be allowed.

5.1.6 Installation of Cables in Conduit

- a) The cable installation in the conduit shall conform to par 6.5.6 of SANS 10142-1 and other portions of SANS, where applicable.
- b) Conduit shall be deburred and swabbed prior to cables being pulled in.

- c) Cables of other classifications and purpose (e.g. DC, Fire Detection, Audio, etc.) shall be installed in separate conduits.
- d) Circuits supplied from different distribution boards shall not be installed in the same conduit.
- e) Final sub-circuits shall not be installed in the same conduit as sub-mains circuits.

5.2 Power Skirting

5.2.1 Construction

- a) Power skirting must comply with all relevant parts of SANS 61084.
- b) Except where room dimensions dictates shortening thereof, in which case only one length per wall may be trimmed, power skirting and covers shall be installed in their standard (manufactured) lengths.
- c) The covers shall either snap on, or shall be fixed by means of toggle or swivel nuts.
- d) Only socket outlets that are compatible for use with the particular type of power skirting may be used.
- e) Propriety internal and external bends, and off-sets of the same manufacture and product range, shall be used.
- f) Over and above the requirements of SANS 10142-1, all conductive power skirting that will contain telecommunication and / or control wiring shall be bonded in accordance with NRS 083-2 (details bonding methods that provide enhanced protection against the effects of electromagnetic cross-interference).

5.2.2 Installation

- a) Conduits for the circuit wiring to the power skirting must terminate in flush conduit boxes behind the power skirting at the respective heights of the compartments for the telephone, power and other service compartments.
- b) Notwithstanding the requirement to provide adequate capacity for the installation of data and telecommunication cables, conduits installed to power skirting installations shall have a minimum of 50 % spare capacity, to allow for future expansion
- c) The wiring shall pass through large diameter holes, suitably bushed, cut in the rear of the power skirting. Where metallic skirting is installed, the holes shall be provided with rubber grommets.
- d) Where power skirting is interrupted by doorways, bridging conduits shall be installed for each of the service compartments.
- e) To allow for the easy removal of plugs from outlets, in multi compartment installations the bottom compartment(s) shall be for telecommunication services and the top compartment(s) for power circuits.

5.3 PVC Cable Trunking

5.3.1 Construction

- a) Cable trunking must comply with relevant parts of SANS 61084.
- b) Cable trunking and covers shall be installed in their standard (manufactured) lengths, except at the end of runs as dictated by room dimensions.
- c) The covers shall either snap on, or shall be fixed by means of toggle or swivel nuts.
- d) Propriety internal and external bends, and off-sets of the same manufacture and product range, shall be used.

5.3.2 Installation

- a) All wiring exiting cable trunking shall pass through large diameter holes, suitably bushed, cut in the rear of the trunking.

5.4 Wiring inside wireways

5.4.1 General

- a) All unarmoured conductors shall be installed in conduits, trunking or power skirting, and such conductors shall not be exposed to possible mechanical damage.
- b) Any debris and moisture inside of wireways shall be removed prior to the installation of conductors.
- c) In the event that lubrication of cables is required in order to facilitate their installation, the lubricant shall be suitable for use with the type of cable as well as the type of wireway. The Contractor shall take steps to ensure that only the minimum amount of lubrication is applied. Should any seepage of lubricants into building elements or fixtures occur, it shall be the responsibility of the Contractor to remove the oil and fix the damaged building elements or fixtures, regardless of whether he installed the wireways or not.

5.4.2 Circuits

- a) The circuits for the installation are indicated on the relevant drawings. Where not indicated on the drawings, the maximum number of points to be connected to each type of circuit shall be:

Table 3: Circuits

Light points per circuit	=	8
Single socket outlets per circuit	=	4
Extraction fan, Air conditioner points per circuit	=	2
Stove points per circuit	=	1

- b) When determining the number of outlets per circuit, double socket outlets count as two single socket outlets.
- c) In kitchens, the number of socket outlets per circuit shall be reduced to 2.
- d) Where maintained emergency lighting are to be installed two live wires shall be installed to the luminaire:
 - i) The normal, switchable, circuit
 - ii) An unswitched circuit, for battery charging only
- e) For 20 mm or small diameter conduit only one circuit will be allowed, 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, par. 6.5.6, shall be met.

5.4.3 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 conduits. Joints shall be soldered or shall alternatively consist of approved ferruling, properly covered with propriety heat-shrink sleeves. The use of PVC insulation tape is not acceptable.

5.4.4 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 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.

5.4.5 Pulling-through of conductors

The Contractor 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.

5.4.6 Earth continuity conductors

- Only stranded copper conductors, which shall be bare or PVC insulated (coloured green/yellow), shall be used as earth continuity conductors. Although it shall be terminated such that it can fulfil this function (except where inappropriate, as will be the case of single core cable installations), under no circumstances shall the armouring and/or shielding of cables be relied upon to provide protective earth continuity.
- When earth continuity conductors are looped between the earth terminals of equipment, the looped conductor ends shall be twisted together and then ferruled or soldered to ensure that continuity is maintained when the conductors are removed from any earth terminal.
- Where bare copper earth wires are specified for circuits installed in power skirting and floor ducting, the Contractor 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.

5.4.7 Wiring inside vertical wireways

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

5.4.8 Conductor sizes

The following minimum conductor sizes shall be used:

Table 4: Conductor sizes

Circuit	Minimum Conductor (Size)	
	Phase (mm ²)	Earth (mm ²)
Lighting	2,5	2,5
Socket outlet	2,5	2,5
Stove	6	6
Bell	1,5	1,5
Clock	1,5	1,5
Air conditioner	4	2,5
Control Wiring	1.5	1.5

5.4.9 Single pole switches

Single pole switches shall only be connected to the phase conductor (never the neutral conductor).



5.4.10 Three phase outlets

- a) With the exception of three phase outlets, wiring 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 to indicate the presence of line 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 socket outlets, irrespective of whether the particular equipment may require a neutral or not.

6. DRAWINGS AND DOCUMENTATION

6.1 General

6.1.1 All drawings, information, and documentation shall be in English, and each item shall be identified with:

- a) The Client's name and contact details
- b) Client's project / scheme / contract reference title and numbers
- c) The Engineer's name and contact details
- d) Engineers reference numbers
- e) Contractor's works / contract / order references.

6.1.2 Drawings for acceptance shall be provided on A4 or A3 paper copies as specified.

6.2 Drawings for Approval

6.2.1 The following documentation and drawings shall be submitted to the Engineer prior to the installation of cables and wireways and before civil construction have started on the areas where cable routes are required:

- a) Cable route layout drawings showing
 - i) Type of wireways
 - ii) Trenching
 - iii) Cable junction boxes

6.3 As-built Drawings

6.3.1 Detailed "as-built" drawings, clearly labelled as such, and consisting of 3 sets of drawings printed to their original size, and, where the original drawings were larger than A3, 3 sets of drawings printed (with reduced scaling, but without omitting any information from the printed area), to A3, shall be provided by the Contractor, indicating positions of the following:

- a) Equipment (e.g. light fittings, draw boxes, outlets etc.)
- b) Wireways (e.g. trenches, conduit, cables ladder/trays, power skirting etc.); and
- c) Cable routes (including any cable joints)
- d) General arrangement drawings
- e) Single Line Diagrams

6.4 Operating and Maintenance Manual

6.4.1 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied. The manuals shall be in A4 format.

6.4.2 The operating and maintenance manuals shall include at least the following:

- a) A schedule of installed components and equipment, containing the following information:
 - i) Manufacturers name and contact details
 - ii) Circuit number (DB name, circuit breaker e.g. DB01-CB08); and

- 
- iii) Function (e.g. switching lighting circuit DB03-L1)
 - b) A schedule of all installed cables, with the following information:
 - i) Circuit number (DB name, circuit breaker e.g. DB01-CB08)
 - ii) Size
 - iii) Installed length; and
 - iv) Function (e.g. "Feeding Submersible pump IW-SP-01")
 - c) Description and details w.r.t:
 - i) Detailed description of the function of all operator controls
 - ii) Procedures for fault finding
 - iii) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures
 - iv) Inspection schedules; and
 - v) Spare part information and recommended spares.

7. TESTING AND COMMISSIONING

7.1 General

- 7.1.1 The installation shall be inspected and tested in accordance with SANS 10142-1.
- 7.1.2 Inspection and testing shall only be performed by personnel with approved, current qualifications. The Contractor shall provide qualified personnel for the supervision for all inspection and testing activities.
- 7.1.3 The Contractor shall provide all necessary safety equipment and test instruments. All test instruments shall comply with SANS 61010 and be covered by a current test and calibration certificate.
- 7.1.4 The Contractor's safe working arrangements shall comply with the safety management systems and procedures prevailing on site. Where there may be a risk of injury to personnel, the Contractor shall submit a risk assessment and method statement for approval, prior to starting work.
- 7.1.5 Unless otherwise specified in the Particular Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10142-1.
- 7.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed. Unless otherwise specified in the Particular Specification, the period of notice for witness testing shall be 5 working days.
- 7.1.7 Where most of the inspection and testing activities are not witnessed, the Contractor shall allow for 10 % of the inspection and testing activities to be repeated for witness testing.
- 7.1.8 If there is a requirement for additional inspection and test activities to be performed as part of process commissioning, this shall be specified in the Particular Specification.
- 7.1.9 Unless otherwise agreed by the Employer, no part of the installation shall be commissioned until all defects or omissions revealed by inspection and testing have been rectified. Where a defect or omission renders all or part of the installation unsafe for use, the Contractor shall take approved precautions to ensure that no part of the installation can be commissioned.

7.2 Test Sequence

7.2.1 Inspections before Testing

Before testing, inspections shall be performed to verify:

- a) All equipment and material is of the correct type and complies with applicable SANS and IEC standards
- b) All parts of the installation are correctly selected and erected
- c) No part of the installation is visibly damaged or otherwise defective
- d) The installation is suitable for the environmental conditions; and
- e) The installation complies with this Specification

7.2.2 Testing of Installation

On satisfactory completion of the inspections specified in 7.2.1 the following tests shall be undertaken in the sequence listed as per SANS 10142-1:

- 
- a) Continuity of conductors
 - b) Resistance of Earthing conductor
 - c) Continuity of ring circuits Earth fault loop impedance at main switch
 - d) Elevated voltage on supply neutral Earth Resistance
 - e) Insulation resistance
 - f) Voltage, main distribution board - no load
 - g) Voltage, main distribution board - on load
 - h) Voltage at available load
 - i) Operation of earth leakage units
 - j) Earth leakage test button
 - k) Polarity at points of consumption
 - l) Switching devices



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