DEPARTMENT OF WATER AND SANITATION
REPUBLIC OF SOUTH AFRICA

DUE AT **11:00** ON

22 DECEMBER 2017

BID NO. W11268

NGQAMAKAWE REGIONAL SUPPLY SCHEME PHASE 5

CIVIL/MECHANICAL/ELECTRICAL CONTRACT

BUTTERWORTH EMERGENCY SUPPLY SCHEME

VOLUME 3: SCOPE OF WORKS : PART B

SUBMIT BID DOCUMENTS

TO

POSTAL ADDRESS:
DIRECTOR-GENERAL: DEPARTMENT WATER AND SANITATION
PRIVATE BAG X313
PRETORIA, 0001

OR

TO BE DEPOSITED IN:
THE BID BOX AT THE ENTRANCE OF ZWAMADAKA BUILDING
157 FRANCIS BAARD STREET
PRETORIA, 0002

ATTENTION:
DIVISION: PROCUREMENT AND PSP ADMINISTRATION
ZWAMADAKA BUILDING
ZWAMADAKA ENTRANCE

BIDDER: (Company address and stamp)

NGQAMAKAWE REGIONAL SUPPLY SCHEME PHASE 5

BID NO. W11268

BUTTERWORTH EMERGENCY SUPPLY SCHEME

LIST OF VOLUMES

CONTENTS

NGQAMAKWE REGIONAL SUPPLY SCHEME PHASE 5

BID NO. W11268 BUTTERWORTH EMERGENCY SUPPLY SCHEME

VOLUME 3

PART C3 – SCOPE OF WORKS

PART C3: SCOPE OF WORKS

PART A:

PART B:

PART C3.3: PARTICULAR SPECIFICATIONS

ELECTRICAL, INSTRUMENTATION AND CONTROL

C3.3: PARTICULAR SPECIFICATIONS

Electrical:

DWS Medium Voltage Equipment

DWS Electrical Colour Code Specification

EE-0010	LV Switchgear & Controlgear Assemblies
EE-0011	Low Voltage Cables
EE-0012	Cable Support Systems
EE-0013	Wiring and Outlets
EE-0014	Lighting
EE-0020	MV & LV Earthing
EE-0021	Lightning Protection for Structures
EE-0022	MV&LV Power Factor Correction
EE-0025	Low Voltage Electric Motors
EL-0001	Fire Detection and Alarm System
EP-0004	Battery Tripping Unit
EP-0008	MV Electric motors
EP-0023	Distribution Transformer
EP-0042	MV Cables

Instrumentation and Control:

II-0001	General Electronic Installations
II-0002	Programmable Logic Controllers
II-0003	Industrial Network Installation
II-0005	SCADA
II-0007	Instrumentation
DWS 9900 C8	Electrical Equipment

MEDIUM VOLTAGE EQUIPMENT

SWITCHGEAR

Switchboards shall be of the totally enclosed, floor-mounted, metalclad cubicle type and shall be vermin and dust proof. The housings and all exterior panels shall be made from sheet steel having a minimum thickness of 2 mm. Switchboards shall be of modular design to allow for the subsequent addition of identical panels. The layout of the panels shall be such that when facing the front of any switchboard, the sequence of panels reads from left to right.

Panels shall be of the truck-mounted type, withdrawable without tools. The fixed portion shall contain all instruments, voltage and current transformers and busbars as specified. All panels shall be fitted with earthing and injection facilities, and be complete with cable boxes to suit the cables terminated thereon. Cable boxes shall be mounted at such a height that cables bending can be more than 12 times the diameter of the cables.

On completing the installation all cables shall be tested.

The switchboard shall be supplied with one full set of probes and earthing devices, housed in an approved cabinet mounted against the wall in the switchgear room.

Panels and panel equipment shall be designed to confine internal arcing faults and to direct arcs and gases arising from these away from the operator.

Measures shall be taken to prevent electrolytic corrosion where dissimilar metals are in contact with each other. To minimise the effect of electrolysis, coils shall be so placed in the circuit that they are not connected to the positive pole of a battery except through normally open contacts.

Where circuit breakers, contactors or switches are provided with doors they shall be provided with non-ferrous fasteners designed to draw the panel closed. The doors shall have at least two points of latching and shall be suitably reinforced to prevent distortion when open. Doors shall have stops to prevent overswing of the door when opening and to prevent interference with adjacent panels. Relay panel doors shall be dust proof. A drawing pocket shall be installed on one panel door for storing line diagrams.

Busbars, circuit breakers, current transformers, low voltage equipment, etc. shall be housed in separate metal enclosures, completely segregated from one another. All openings, joints, etc. in the switchgear shall be completely vermin proof. Screws, bolts, nuts and washers used in the assembly of the switchgear shall be zinc plated and chrome-passivated before use. Switchgear shall be designed to be a continuous assembly in a straight line, capable of being extended at either end, and shall be suitable for installation on a flat, finished concrete floor.

Bolts shall be of the correct size for the holes provided and shall be fitted with matching size washers and locking devices. Where removable panels are provided with bolt fastening, the nuts shall be either welded in position or securely fixed by means of a mechanical fixing device. Self-tapping screws, captive head nuts or cage nuts are not acceptable. All welding joints shall be smoothly finished and all metal shall be thoroughly cleaned before painting.

A copper bar with minimum cross-sectional area of 180 mm^2 shall be supplied along the entire length of the switchgear. All metal parts of each circuit breaker or switch shall be thoroughly connected to this earth bar. Provision shall be made for the addition of future switchgear. Earth terminals shall be supplied on both extreme ends at the rear of the switchgear at a height of approximately 150 mm above floor level. The earth bar will be earthed at both ends of the switchboard and provision shall be made for this. The earth bar shall be in an accessible position to allow for earthing of the cables. The non-current carrying parts, including relays, meters, etc., shall be connected to the earth bar either by means of their mounting arrangement on the panel or by means of a special earth fitting with lugs for attaching to the earth bar.

Automatic safety shutters shall be provided at all busbars, cable and voltage transformer openings. Provision shall be made for these safety shutters to be padlocked in the "CLOSED" position.

Control circuits shall be fitted with multi pole MCCB's. There shall be at least one pole in the positive circuit and one pole in the negative DC control circuit. An auxiliary contact that closes when the MCCB is open shall be included and wired to a pair of alarm terminals at the rear of the panel. The MCCB's shall be adequately rated for the appropriate load and fault breaking duty and supply, whether AC or DC. Labels shall be provided to indicate the MCCB rating and duty. The Contractor shall ensure that the MCCB's are capable of proper co-ordination for all fault types and positions. The DC supply bus wires shall be separated at all terminals by a distance of at least 25 mm in order to reduce the probability of a fault. These terminals shall be adequately shrouded.

Unless otherwise approved, trip-free mechanisms are to be provided. Means shall be provided to prevent pumping i.e. when the closing circuit remains energised and the circuit breaker either fails to latch or trips, while being closed, due to protective relay operation. The arrangement shall be to the approval of the Engineer. Anti-pumping relays shall be continuously rated.

Panels shall have shunt trip coils capable of correctly operating even when the control voltage is reduced to 50% of the rated DC control voltage which is applied directly to the coil terminals when the circuit breaker is carrying normal rated current. Circuit breakers shall be capable of operation down to 80% of rated DC control voltage when the circuit breaker is carrying full rated fault current.

Panels shall be fitted with the specified number of spare auxiliary switches. Where the number of auxiliary switches on the breaker contact block is insufficient for the purpose, the additional contacts shall be provided via a bi-stable relay with operate and reset coils. Both coils shall be provided with cut-off contacts to open the coil circuit once the coil has been energised and the relay has changed position. The auxiliary relay shall be energised from the breaker closing circuit supply. At least two N/O and two N/C spare contacts driven directly by the breaker shall be provided.

A mechanical indicating device to show whether the isolator or switch is open or closed shall be provided. This device shall be labelled as follows:

- 'ON' – White lettering on a green background.
- 'OFF' – White lettering on a red background

The above labels shall be clearly visible from the front of the panel. The lettering size shall not be less than 10 mm. The method of fixing of labels shall be to approval. The above labels shall correspond to the end of positions of the operating handle. All labels shall be mechanically strong and shall preferably consist of white/black/white traffolyte or anodised aluminium. They shall be permanently fixed with screws. Danger notices shall be red with white lettering. Main designation labels shall be fitted to the front and back of each panel. Danger signs shall be fitted, where necessary, in accordance with the Occupational Safety and Health Act (OSH Act). Each switch, relay and instrument shall be fitted with an approved label to indicate its function. All labels shall be in English. Labels pertaining to circuit breaker operating procedures shall be mounted outside the panel door. The location of, designation, spelling, size of lettering and method of fixing labels shall be presented to the Engineer for his approval prior to their manufacture and attachment.

One hand-closing device shall be provided with each switchboard in order to enable the circuit breakers/contactors to be closed by hand during maintenance only. Wall-mounted brackets shall be provided for carrying the manual operating handles. A complete set of finished casehardened spanners and special wrenches to fit every nut and bolt on the equipment supplied shall be provided. Any special tools or keys that may be required for effecting adjustments of parts shall also be provided. The above tools shall be fixed in clips and be accommodated on a suitably neat and properly designed wall-mounted equipment board. This board shall be constructed from steel with the tool positions marked. The board shall be capable of being locked by means of a padlock. A fully detailed list of tools shall be supplied before delivery. The above tools shall not be used for the erection of the contract works.

INSTALLATION AND TESTS

The Contractor shall supply all information concerning the openings for foundation bolts, placing of steel channels in the floor, special cable requirements, etc., to the Engineer within one month of award of the order. If the information is incorrect or if no information is provided, any remedial work ensuing will be to the account of the Contractor. When a building, switch room, dam wall or weir is erected under a separate contract by others, the Electrical Contractor shall assist the Building Contractor with the positioning of sleeves, cable trenches, manholes, etc., in spite of the fact that these materials are provided and installed by others. The Contractor shall ensure that galvanised drawn wires are placed in all sleeves during installation.

The Engineer shall be notified, at least two weeks before despatch, that switchgear is available for his inspection at the Manufacturer's premises. The Engineer also reserves the right to witness any routine tests at the Manufacturer's premises.

Switchgear shall be positioned as indicated in the Specification or on the drawings. Where a complete switchboard, consisting of separate MV circuit breaker panels, switches etc. is supplied, a single line diagram will serve as guidance with regard to the layout of the panel.

Switchgear in substation buildings, with the exception of oil or fuse switches, shall be installed with the front of panels aligned. Where required, shims shall be placed under the switchgear to ensure that the complete installation is level.

After all the required tests have been performed to the satisfaction of the Engineer, the switchgear shall be energised and this shall not take place without prior approval of the Engineer.

All circuit breakers, contactors, switches and fused oil switches shall be subject to type tests as called for by the applicable standards. For each circuit breaker, contactor or switch type supplied, the Contractor shall provide copies of type test certificates, giving the results of rupturing capacity tests according to the relevant standards, as carried out by a recognised test centre.

On completion of manufacture of switchgear, the following tests shall be conducted at the manufacturers' works:

- An operational test on all circuit breaker operating mechanisms including the raising and lowering of the circuit breaker, checking of mechanical interlocking, spring charging mechanisms and all opening and closing systems
- A primary injection test at not less than full rated current to verify the tripping times of and operation of all over current, earth fault and other protection relays. This test will also verify the current transformer rations and polarity
- An primary injection and voltage test on all metering circuits to ensure the correct connection and operation of all power meters and verify the current transformer ratios and polarity
- Primary current injection tests shall be made on all power circuits containing CT's to check occurrence of ammeters, and calibration of relays. During the overload and earth leakage tests, the circuit breaker shall be closed to confirm tripping of the circuit breaker under fault conditions
- The testing and checking of all indication lamp circuits and the operation of lamp test and associated circuits
- The testing of all alarms circuits
- 2 kV pressure test to earth on all auxiliary low voltage circuits

- Insulation resistance test with a 2000 Volt insulation resistance tester measuring the power and secondary wiring to earth. A minimum value of 1000 and 200 Megaohms respectively is required
- High voltage pressure tests on the equipment between phases and between phases and earth such that all combinations are fully tested
- Test all auxiliary relays for correct operation
- Test all trip, close and control circuits for correct operation

Tests on site shall be the tests specified for each item of plant in the relevant British or other approved Standards and the tests shall be conducted in accordance with the Contract. The Contractor shall provide all equipment and personnel required to carry out the tests, including provision, installation and removal of all test instruments, the connection and disconnection of plant items and obtaining of all records. The Contractor shall prepare and submit to the Engineer at least two month prior to the commencement of testing, schedules in approved format for each test together with a program for the Tests on Completion. The Engineer will be responsible for overall co-ordination and safety control of tests. The Contractor shall submit one copy of the result of each of the tests at Site to the Engineer within one week of the tests being carried out. Four copies of the certified results of each of the tests at Site in the form of test reports or tests certificates shall be provided to the Engineer within one month of the tests being carried out. The staff of the Department shall be invited to observe and participate in the Tests on Completion. The tests on completion shall be carried out and passed before the taking over of the Works by the Employer shall consist of three main stages of testing as follows:

Preliminary tests: tests performed prior to rotation of, energising at normal voltage or admission of normal water pressure to the main or auxiliary plant under tests and including insulation and continuity tests on wiring and cabling checking as appropriate for output, accuracy, repeatability, and correct operation of each individual item of control and auxiliary plant which is of mechanical, electrical or hydraulic operations checking that no loose or foreign material has been left in the plant.

- Proving tests including dielectric tests
- Operational tests to progressively prove the correct operation of complete auxiliary systems and of the main plant

After the Plant has been set to work and the Contractor has ascertained that the Plant is working correctly, the Tests on Completion shall be carried out.

It should be noted that inspection and witnessing of tests shall not relieve the Contractor of his responsibility for meeting all of the requirements of the Specification. It shall also not prevent any subsequent rejection, if such material or equipment is later found to be incorrect or defective. The Contractor shall be responsible for all tests. However, the Engineer reserves the right to appoint an independent party to conduct any tests required in order to prove compliance with this Specification. The cost of such tests shall initially be borne by the Client. However, should these tests prove any equipment to not comply with this Specification, all costs to ensure compliance and of any subsequent tests, which the Engineer may require, at his discretion, to prove such compliance, shall be borne by the Contractor.

After installation and before commissioning, the following site tests shall be carried out on the switchgear in the presence of the Engineer or his representative. Three copies of the relevant test certificates shall be supplied by the successful Tenderer:

- DC voltage tests on the main and secondary circuits in accordance with BS 162, BS 5227 or IEC 298.
- Insulation resistance tests.
- Primary and secondary current injection tests to prove the operation of current transformers, protective relays and ammeters.

- Earth continuity and earth resistance.
- Mechanical and electrical functional tests.
- After the switchgear and other equipment has been installed and connected, a high voltage of approved value shall be applied to primary equipment for an approved period.
- The continuity and phase rotation of all circuits shall be tested.
- Rotation and polarity tests shall be carried out on all current transformers.
- Each current transformer shall be checked to ensure that it is earthed at one point only.
- All raising and lowering mechanisms for busbar and cable shutters of circuit breakers shall be checked in order to ensure that they operate properly.
- The manual and electrical close and trip mechanism of each circuit breaker shall be tested and the semaphore indicator(s) checked.
- All electrical and mechanical indicators shall be checked to ensure that they function correctly.
- All circuit breaker interlocks shall be checked to ensure that they are working properly.
- All isolating switches, earthing switches and associated interlocks shall be checked in order to make sure that they are working correctly.
- All connections to the earth system shall be checked for correctness.
- All alarms, indicators, tripping units, fuses and switches shall be checked separately.
- Tripping units shall be checked for proper operation at 50% voltage, as specified in BS 5311: Part I.
- Each circuit breaker shall be checked with the tripping coil energised, to prove trip-free operation.
- The insulation of all secondary wiring circuits shall be subjected to a voltage withstand test.
- The insulation resistance of all secondary wiring shall be determined.
- Ratio and insulation resistance tests shall be carried out on all voltage transformers.
- The earthing of their cases and windings shall be checked.
- The resistance of the earthing system shall be measured according to CP 1013.
- All circuit labelling shall be checked.
- The control, protection, instruments, metering equipment and circuits shall be tested to prove compliance with the tests described.

Overall testing of circuits for equipment with remote connections not included in the switchgear contract, e.g. pilot wire protection stability, remote controls etc. may be the responsibility of others but the switchboard manufacturer shall be responsible for proving that his equipment and circuits are correct up to his output terminals.

Earthing resistance shall be measured with a measuring bridge, which operates on the Schlumberger or Werner principle. The Contractor shall supply the necessary apparatus and shall demonstrate to the Engineer how the tests are carried out, in order to ensure that correct procedures will be followed. As a general directive, the earth resistance shall not exceed the following values. The Engineer may, however, approve higher values under certain circumstances:

- MV earthing – 2 ohm
- LV earthing – 1 ohm

Earth tests shall be performed at all earth points, i.e. at any apparatus or equipment that is connected to the earthing system. The Contractor shall keep a complete record of all values measured at these points and shall submit it to the Engineer for approval. To verify the records, the Engineer has the right to request the repetition of the measurements, without any charge to the Department.

MV and LV earthing systems shall be kept separate. If the resistance of the MV system is 1 ohm or less, the neutral of transformers may be connected to the MV earth electrode.

COMPONENTS

Busbars shall be copper, factory epoxy resin encapsulated, air insulated. Bolted joints shall be shrouded. Busbars shall conform to BSS 159, in enclosed compartments with clearances to BSS 162, adopted to site conditions. Busbar design shall be in accordance with BS 158 and BS 159. Bushings shall comply with BSS 223. Unless otherwise approved all busbars and droppers shall be hard drawn copper and have suitable dimensions, which comply with BS 159. Allowance shall be made for temperature rise at the specified altitude. The busbars shall have sufficient mechanical strength for the rated load and potential fault conditions. Busbar chambers shall be fully segregated from the rest of the panel and from other busbar sections. Busbars shall be of hard drawn high conductivity copper suitable rated and braced on either epoxy or porcelain insulators and with sufficient clearances to suit the system voltage. Busbars joints shall be bolted using high tensile steel bolts, flat washers and lock nuts.

All busbars shall be of the fully insulated type on all sections where possible. Air clearances other than those specified in BS 159 and BS 158 shall be subject to engineer's approval. Busbars shall be colour coded to the approval of the engineer. All insulating materials shall be resistant to flame propagation, non-hydroscopic and resistant to tracking. Where necessary earthed screens of metal or semi-conductive material shall be provided to eliminate corona discharge. Busbars shall be covered with insulating material over their full lengths, except at connections and joints. The latter shall be completely enclosed by jackets or shrouds and filled with an approved insulating material. The use of insulation tape on busbars, connections or joints shall not be accepted.

All joints and tees in busbars and busbar connections shall preferably be made with sheradised bolts, nuts and washers of not less than 12 mm diameter. High tensile (black) bolts of not less than 10 mm diameter and having a reference symbol 'R' for the tensile range in accordance with BS 970 will be accepted as an alternative. Proof of the tensile range shall be provided. Joints shall be made with at least two, preferably more, bolts and the overlap shall be sufficient to ensure ample mechanical strength and joint conductivity and unless otherwise approved shall not be less than six times the thickness nor less than the width of the busbar material, whichever is the greater. Particular attention shall be paid to such matters as appearances, effect of altitude on clearances, creepage distances, joints, thermal expansion provision, mechanical strength including stresses due to electrical short-circuit conditions.

Busbars shall have minimum continuous and short circuit current carrying capacities as stated in the Specification and shall be separately housed in an air-insulated compartment. Full account shall be taken of thermal expansion and mechanical forces in busbar systems under fault conditions. For these purposes an initial busbar temperature of 90°C and a peak short circuit current equal to 2,55 times the specified symmetrical short circuit current may be assumed.

The busbars and the circuit connections to the busbars shall have normal current rating as indicated in the specification. Busbars shall be of copper having an adequate cross-sectional area and complying with the relevant requirements of BS 1432. Busbars shall be supported by insulators designed to withstand any voltage expected to be applied. All busbars and connections shall be insulated with insulation capable of withstanding the voltage levels specified in the Specification. All connections to busbars shall be colour coded as follows, as seen from the front of the panel:

- Red – Left
- White – Centre
- Blue – Right

All isolators shall be of the "load-break and fault-make" type. The isolators shall have the ratings as specified. Fuse switches or isolator enclosures shall be provided with an interlocked cover to ensure that the switch is in the "OFF" position before the cover can be opened for inspection or fuse removal. It shall not be possible to close the switch without the covering being closed. Fuse switches or isolators shall be provided with a clear "ON/OFF" or "I/O" position indicator. Changeover or busbar selector switches shall also be provided with suitable position indicators.

Each MCC shall consist of a load-break and fault-make isolator in combination with a fused contactor. In addition, the MCC shall contain a separate set of MV HRC striker pin fuses for the protection of externally mounted power factor correction equipment. The above isolator shall be visible through a clear panel when the door of the MCC panel is open. The MCC panels are required for the starting and control of motors and the protection of associated power factor correction equipment. The motor control centres shall in general comply with the relevant requirements of the Specification. The panels shall be complete with all equipment, internal wiring and labels. In addition to external labelling, all internal equipment (relays, contactors, CT's, fuses, etc) shall be clearly labelled with labels indicating function and circuit identification. Each MCC shall be housed in an individual panel. The panels shall, in combinations with the other MV switchgear, form a continuous assembly with the fronts of the panels in a straight line.

When MV compartments are opened, all live equipment shall be clearly indicated as such by means of white lettering of the largest possible size on red celeron labels. Instrument test blocks shall be provided. Test blocks for protection circuits shall also be provided.

Two sets of HRC fuses are required, the first set being for the protection of the motor, and the second set for the protection of the associated remotely mounted power factor (PF) correction equipment. Both sets of fuses shall be of the type employed for motor starting applications, and shall be fitted with striker pins. The fuse links shall have current/time characteristics such as to limit fault currents to less than the rated symmetrical fault current rating of the associated main motor contactor. Labels shall be fixed in prominent positions near the fitted fuses, with a label bearing the wording:

"WARNING - REPLACEMENT FUSE LINKS TO BE EQUIVALENT TO THOSE IN USE AS APPROVED”

On operation, the striker pin of the motor fuse shall activate a limit switch and/or relay which shall ensure interlocking as described further on, and give indication of a blown fuse. Separate indication is required for motor and capacitor fuses. A spare set (set = 3 fuse links) motor fuse links shall be supplied with each MCC.

Contactors shall in general comply with the requirements of the latest issue of IEC 470. Tenderers shall offer vacuum contactors only. Contactors shall be of the electrically held type with 110 VDC operating coils. A capacitor of suitable rating shall be connected across the terminals of the coils, so as to delay de-energising of the coil for 300 ms, in the event of a dip in the 110 VDC control supply voltage. Contactors shall be designed to carry the continuous rated current without exceeding the applicable BS specified temperature rise. The symmetrical rms breaking capacity shall be at least 25 MVA at the rated voltage, and the rated 1 second thermal short time current shall be at least 25kA. The contactors shall have mechanical and electrical lives of 2 million and 1 million operations respectively, at 95% AC3 and 5% AC4 duty. Current chopping and pumping shall be reduced to a minimum. Full details of the inherent chopping current particulars of the contactor shall be submitted with the tender. The contactor shall be inhibited from closing in the event of any of the interrupting bottles becoming faulty. The contactor shall have at least four normally open and four normally closed spare auxiliary contacts. These spare contacts shall be wired out to a clearly labelled terminal strip in the control compartment.

NOTE: – Spare = available after all factory wiring has been completed.

The tenderer shall, for each MCC, include in his offer three single-phase surge suppressers, suitable for mounting in the motor terminal box. The tenderer's offer shall include all material and labour for the installation and connection of the suppressers.

Protection devices and equipment (relays, CT's etc.) as required by the Specification shall be provided. Besides the specified interlocking, the following interlocks shall be provided:

- Opening of the switch must only be possible after the main contactor has been opened or tripped
- Switch has to be closed before contactor can operate, except when NORMAL/TEST switch is in TEST position
- Switch has to be open before access to MV compartments is possible
- A blown fuse link shall trip the contactor and inhibit closing of the switch, once it has been opened

The motor protection relay shall have an auxiliary contact to indicate when the motor is in a "cooling down" cycle after being tripped. In addition, closing of the motor contactor shall be inhibited during this cycle.

A horizontal draw-out carriage housing the power fuses and main contactor shall be provided within a segregated front section of the panel for motor starters. Indications provided on the front of the draw-out carriage facia shall include:

- Mechanical ISOLATED/ENGAGED indication
- Mechanical CONTACTOR ON/OFF indication
- Mechanical FUSE HEALTHY/BLOWN indication
- Operating instructions for insertion and isolation of the draw-out carriage
- PROTECTION SYSTEMS

Each circuit breaker and contactor shall be fitted with protection and auxiliary relays as specified in the Specification. Where the circuit breaker or contactor is to be equipped for remote indication and control, all the auxiliary relay switches shall be wired to an easily accessible terminal block on the back of each panel. These panels shall have thermal O/L, unbalance and delayed EF protection. Phase fault protection is provided by suitably rated fuses. The PF correction capacitors are fused separately and 2 flag relays shall be provided to indicate which fuses (main or capacitors) have blown to open the contactor. The instantaneous elements of the motor protection relays, OC and EF, are used to block the MV bus zone protection.

All relays shall be of the flush, panel mounting draw-out type and shall be clearly labelled by means of separate engraved labels mounted on the panel to indicate their respective functions and shall be contained in dust proof cases. Relays shall comply with the latest issue of the following standards: - IEC 255, BS 142 and SEN 36.15.03. All relays shall be capable of operating continuously over the auxiliary DC supply voltage range of ± 20% of the specified nominal DC voltage over the ambient temperature range of 0-55°C. Relays providing short-circuit or earth-fault protection shall be DC operated.

Relay terminal studs shall not be less than 5 mm diameter, or, alternatively, relay connections shall be of an approved plug-in type. Relays shall be with self-resetting targets. The targets shall not operate until the relay has closed its tripping contacts and resetting shall be accomplished without opening the case. The targets shall not be tripped by vibration caused by normal or fault operation of the associated circuit breakers. Relay contacts shall be capable of repeatedly making and, where the circuit renders it necessary, repeatedly breaking, without deterioration, the maximum current possible in the circuit they control for at least the maximum duration of a fault as is set by the protective devices. Where more than one set of contacts is provided, all contacts shall operate simultaneously. Tripping contacts shall not close due to vibration engendered by the normal or the fault operation of the associated circuit breakers. Unless otherwise specified, the relays shall be fitted with self-resetting contacts. Where hand-reset relays are specified, resetting shall be accomplished without opening the case. All hand-reset relays shall be accessible to a person of normal height standing on the floor, unless otherwise approved. Hand or electrically reset relays shall be provided with an additional contact connected internally to interrupt the operating coil current. Electrical-reset relays shall, in addition, if called for the provided with a contact connected internally to interrupt the resetting coil current. Electrical-reset relays shall preferably also be fitted with hand-resetting features. Combined measuring protective relays shall be equipped with means to indicate whether the operation was due to phase over current, earth-fault, high set instantaneous or inverse time. Where high set relays are provided with or combined with a time delay, the high set current relay operation shall only be indicated when the associated time delay has expired.

Relays shall be fitted with hand-resetting operation indicators. These indicators shall not operate until the relay has closed its tripping contacts and resetting shall be accomplished without opening the case. The indicators shall not be tripped by vibration caused by normal or fault operation of the associated circuit breakers. Relays with operation indicators shall be mounted on the front of the switchgear instrument panels. Relays without indication shall be mounted inside the instrument compartment. Relay contacts shall be capable of repeatedly making and, where the circuit renders it necessary, repeatedly breaking without deterioration, the maximum current possible in the circuit they control for at least the maximum duration of a fault as is set by the protective devices. Where more than one set of contacts is provided, all contacts shall operate simultaneously. Tripping contacts shall not close due to vibration engendered by the normal or the fault operation of the associated circuit breaker.

All relays shall be provided with test blocks to permit tests to be carried out on the relay while in position on the panel without disconnecting any wiring. These test blocks may be either included in the relay case or separately mounted. If separately mounted, they shall be of a design approved by the Engineer and included in the switchgear manufacturer's contract. They shall not be of the "metering" type requiring screwdrivers to gain access to or for shorting of the CTs, but of a type able to accept a test plug to which the instruments and/or test equipment can be connected in advance. The number of test plugs specified shall be supplied separately for each type and make of test block, as an integral part of the switchgear contract. At least one test plug for each type of test block shall be included in the contract automatically. All measuring relays shall be supplied with built-in test facilities to enable secondary injection testing and measurement of currents, voltages, time delays and operating characteristics without disturbing any connections and without danger of opening CT circuits on load or causing false tripping. These test facilities shall be to approval. The supply of two test handles/plugs of each size and type shall form part of the contract.

Static relays shall have a built-in test facility to allow trip testing of the associated circuit breaker without the need for secondary injection merely to achieve this objective. The trip test shall require the deliberate operation of two or more test/reset buttons simultaneously. At least one of the test buttons shall only be accessible with the relay cover removed. The test operation shall result in the closing of the relay trip output contacts thus simulating an actual trip operation.

The number of contacts provided on each relay shall be as specified in the schedule or drawings. Unless otherwise specified, contacts shall be available for external use and shall be individually wired. Hand reset relays shall be provided with an additional contact connected internally to interrupt the operating coil current. Electrically reset relays, if called for, shall in addition be provided with a contact connected internally to interrupt the resetting coil current. Electrically reset relays shall preferably also be fitted with hand-reset features. Make contacts shall be taken to mean contacts that are open when the relay is de-energised or reset. Break contacts shall be taken to mean contacts that are closed when the relay is de-energised or reset.

Tripping duty contacts shall be capable of making and carrying 30A DC for 200 ms in a circuit with a L/R of > = 10 ms. Breaking duty contacts shall be capable of breaking the current of the associated controlled device or the specified breaking current in a circuit with a L/R of < = 40 ms. Relay contacts shall be capable of repeatedly making, and, where the circuit renders it necessary, repeatedly breaking the maximum current possible in the circuit they control without deterioration. Where more than one set of contacts is provided, all contacts shall operate simultaneously. Tripping contacts shall not close due to vibration of any type whether engendered by the normal or the fault operation of the associated circuit breakers, the closing of panel doors, swing frames or other shocks to the panel. Unless otherwise specified, the relays shall be fitted with self-resetting contacts. Where hand reset relays are specified, resetting shall be accomplished without opening the case.

All hand-reset relays, or relays with hand reset operation indicators, shall be accessible to a person of normal height standing on the floor unless otherwise approved. Care shall be taken to ensure that the instrument compartment doors can be opened to their full extent without fouling the relays or instruments on adjacent panels.

On circuits controlling motors, trip signals from motor control consoles will be divided into two categories with separate circuits:

- Normal control "stop" signals
- Mechanical protection trip signals

A counter and/or approved flag indication as described below shall be provided on the MV switchgear panel to indicate the number of each type of operation impulse received. The flag indication of a normal "stop" control signal, type shall be such that it operates on receipt of the stop signal and is automatically reset on receipt of the next "close" or "start" control signal. The flag indication of a remote mechanical protection trip indication, type shall be of the hand-reset type.

Instrument compartment doors shall be provided with one square key catch (top) and one lockable handle operated catch (bottom). They shall also be provided with neoprene or other approved seals to prevent the ingress of dust.

Relay terminals shall be of an approved system. Terminals of the following types are not acceptable:

- Fast-on connectors
- Terminals with clamping screws where the screws are in direct contact with the wire crimped-on termination
- Unless the panel is being supplied as a complete system, terminals of the wire wrap or equivalent type

Relays shall preferably be of the fully draw-out type where the whole relay can be withdrawn from the case for replacement, testing and maintenance. Where this is not a feature of the design, individual modules and/or PC Boards shall be of the plug-in type. The removal from the housing, rack or case of current transformer fed components of any relay shall automatically short-circuit the CT circuits.

Unless otherwise specified the relays shall be provided with latching type indication of the operation of each individual protective element. These operation indicators shall only operate when the relay gives a trip output. Preference will be given to relays whose indications have a memory so that the indication is not lost if the DC auxiliary supply is switched off temporarily. Every relay that provides a trip or alarm output shall either have an integral operation indicator or a separate unit, which will indicate clearly and without doubt the fact that, the relay has operated. Each trip function of all relays shall have a separate operation indicator. Measuring relays that initiate time delay relays shall not operate their associated indicators until the time delay has expired. Resetting shall be accomplished without opening the case. Operation indicators shall not operate incorrectly if the panel is subjected to vibration or shocks of any type.

Where the panel is to be equipped for remote indication and control, all the relay auxiliary switches shall be wired to an easily accessible terminal block on the back of each panel. Allowance shall be made for additional terminal blocks on every panel for testing purposes if solid state relays are offered. Combined solid state over current and earth fault relays must be equipped with indicating flags or lamps showing the nature of the fault.

The protection shall comprise of:

- three phase thermal overload
- negative sequence current detection
- Earth-fault protection.

The relay shall have inverse-time characteristics and a memory to match the motor thermal characteristic. Relay characteristics shall preferably be selectable as follows:

- When starting from the hot or cold condition
- When running
- When stationary and cooling down after running at steady full load temperature (preferable).

NOTE: – Unless the motor permissible locked rotor time is less than the starting time with the design load connected, (see below) this relay shall:

- permit motor starting without undesired tripping (negligible overshoot)
- provide stalling protection for stalling at start or from the running condition

NOTE: – If the permissible locked rotor time of the motor is less than the normal starting time, additional locked rotor protection, to the approval of the Engineer, shall be provided.

The thermal overload setting shall be continuously adjustable over at least the range 50 – 120% of the relay current and operation shall occur at between 102 – 107% of the setting. An adjustable overload time delay at 5 times the thermal setting of at least 4 – 16 seconds is preferable. Alternatively the relay supplied shall be capable of permitting a selectable number of starts of the motor per hour preferably at 20 minute intervals unless otherwise stated in the Specification. It shall be possible to limit the number of starting attempts in a given period and to set the nominal motor starting time on the relay. The relay shall have an indication instrument capable of displaying the load at which the motor is operating as a percentage of the "trip temperature" setting (preferable). A thermal reset facility for relay testing shall be provided. This shall not be accessible from outside the relay case. On loss of the auxiliary supply the relay's thermal memory shall preferably decrease at the selected cooling rate for at least 1 hour.

The protective relay shall be capable of detecting negative sequence current which is harmful to the motor, but shall be free of nuisance tripping for negative sequence currents which will not cause overheating. Relays that measure current unbalance only are not acceptable unless the manufacturer can prove to the satisfaction of the Engineer that the method of unbalance detection can be related to the negative sequence current with a tolerance not exceeding ± 10%. The negative sequence sensitivity shall preferably be adjustable over the range 10 – 30% of the positive sequence setting. The tripping time for potentially harmful negative sequence currents shall have an inverse characteristic to match the thermal capability of typical motors, or shall be adjustable over the range 1 – 10 seconds. The provision of a high set time delayed negative sequence relay to protect the motor against starting attempts with an open phase is a desirable feature. This should have a setting range of the order of 50 – 250% of rated current and an additional time delay setting of 0,5 to 1 second.

The relay shall have an element capable of detecting earth-faults on the stator winding, and of providing independent contacts for a high speed instantaneous bus zone blocking signal and for a delayed tripping signal. The time delay for the trip signal shall be adjustable over the range of 0,5 to 1 second. The two sets of contacts shall be wired out to separate terminals. A continuously adjustable stabilising resistor shall be supplied to ensure that the relay cannot trip incorrectly during motor starting. The relay current setting shall be of the order of 10 – 20% of the relay rated current and the voltage setting with the stabilising resistor, of the order of 0 – 30 V for 5A CTs and 0 – 150V for 1A CTs. The stabilising resistors shall be continuously rated at the maximum setting voltage and the temperature rise shall not exceed 50°C at this rating. If externally mounted, the hardware for mounting the resistors shall be provided.

Under voltage relays and single phase relays shall be instantaneous or definite (independent) time-delayed relays, as specified, having a drop-out setting range of 60 – 100% and a pick-up/drop-out (resetting) ratio not exceeding 103%. The time delay, where specified, shall be adjustable over the range 0,5 – 3 seconds and the relay shall have a hand reset operation indicator which only operates on expiry of the set delay. The relay shall operate in the "fail safe" mode, unless otherwise specified, so that loss of AC measuring signal or auxiliary DC shall result in tripping of the associated breaker or contactor, or blocking of motor starting. The relays shall be provided with two sets of independent trip duty contacts, one set for the instantaneous feature and the other for the delayed feature, wired out to separate terminals. These contacts shall preferably be of the changeover type.

The following information concerning the relays shall be submitted with the tender:

- Complete descriptive information in English explaining the operation of the relays for internal and external faults and the methods for determining the required settings, CT and VT characteristics, etc. and for testing the relays
- Circuit diagrams of relays
- Outline dimensions of relays or 19" rack assemblies
- Schematic diagrams of overall protection schemes
- Detailed block diagrams for printed circuits in the case of electronic relays
- Deviations from the Specification
- Outline dimensions of cubicles

All static relays and electronic equipment shall comply with the requirements of IEC 255-4 and SEN 36.15.03, particularly in respect of:

Insulation tests

- Dielectric test: 2 kV, 50 Hz, 60s, all circuits to contact circuits and to ground (routine test)
- Impulsive voltage test: 5 kV, 1,2/50 us, 0,5 Joules (class II) (Type Test)
- Contact Test: 1 kV, 50 Hz, 60s across open contacts (unless otherwise specified) (type test)
- Disturbance test (Type test)
- Fast Transient test: 2 minutes at 4 – 8kV (to SEN 36.15.03)
- 1MHz Test (2 sec)
- Common mode 2,5 kV

- Transverse mode 1 kV) Class III
- Vibration test
- Relays shall comply with the requirements of BS142 in respect of vibration withstand capability
- "Scratch" Test (Type Test)

The relays shall not operate incorrectly if the DC supply is disconnected or if it is interrupted intermittently in a random fashion, eg by a loose contact in the circuit. To prove this the relays shall be subjected to the so-called "scratch" test where the DC supply is fed via a metal file and a loose lead "scratched" across the surface of the file at random speeds. The test shall be repeated with files of different coarseness. No relay operation shall occur during this test. The tests shall be carried out with the AC circuit de-energised and also when energised at rated voltage and/or current.

Department of Water Affairs - Colour Codes for Lights, Buttons and Switches - Version 1 - 6 September 2010

PUSH BUTTONS AND SELECTOR SWITCHES

TECHNICAL SPECIFICATION	
DESCRIPTION	REQUIREMENT
PUSH BUTTONS AND SELECTOR SWITCHES	
INGRESS PROTECTION	IP 65
INGRESS PROTECTION	IP67 WITH SILICONE PROTECTIVE COVER
CONTACT BLOCKS	UP TO 6
MOUNTING HOLE	22-22.5 MM
OPERATING TEMPERATURE	-25 TO +60 CELCIUS
ADDITIONAL REQUIREMENT	CE MARKING

ITEM	COLOUR OF THE BUTTON	COLOUR OF THE FRAME (IF APPLICABLE)	ADDITIONAL FUNCTIONALITY OR DESCRIPTION	AS APPLICABLE ON: MOTORS	VALVES	CIRCUIT BREAKERS AND ISOLATORS	POWER SUPPLY INDICATION	HYDRAULIC SYSTEMS	BATTERY CHARGER	OVERHEAD CRANES	OTHER APPLICATIONS
	PUSH BUTTONS AND SELECTOR SWITCHES								PUSH BUTTONS AND SELECTOR SWITCHES		
B 1	RED		PUSH BUTTON	STOP	CLOSE	OPEN			Not Applicable		STOPPED, STANDING, STATIONERY, NOT DOING WHAT IT WAS DESIGNED TO DO, ABNORMAL CONDITION
B 2	RED		MUSHROOM TYPE, LATCHING	EMERGENCY STOP	EMERGENCY STOP	EMERGENCY STOP			EMERGENCY STOP		EMERGENCY STOP
B 3	GREEN		PUSH BUTTON	START/RUN	OPEN	CLOSE			Not Applicable		MOVING, RUNNING, FLOWING, DOING WHAT IT WAS DESIGNED TO DO
B 4	WHITE		PUSH BUTTON	LAMP TEST FOR ALL PANEL LIGHTS, PUSH BUTTONS ETC.							
B 5	BLACK		PUSH BUTTON	FAULT CONDITION ACCEPTED, FLASHING STATE CANCELLED							
B 6	BLACK		SELECTOR SWITCH	FUNCTIONALITY AS REQUIRED							
B 7	BLACK		LOCKABLE SWITCH	FUNCTIONALITY AS REQUIRED							
B 8	BLUE			FUNCTIONALITY AS REQUIRED							
B 9	YELLOW			FUNCTIONALITY AS REQUIRED							
B 10	GRAY			FUNCTIONALITY AS REQUIRED							
	PUSH BUTTONS AND SELECTOR SWITCHES								PUSH BUTTONS AND SELECTOR SWITCHES		

PUSH BUTTONS AND SELECTOR SWITCHES

Department of Water Affairs - Colour Codes for Lights, Buttons and Switches - Version 1 - 6 September 2010

CONTROL PANEL LIGHTS

TECHNICAL SPECIFICATION	
DESCRIPTION	REQUIREMENT
CONTROL PANEL LIGHTS	
TYPE	LED (LIGHT EMITTING DIODE)
ARRANGEMENT	MULTI / CLUSTER TYPE
OPERATING CURRENT	16 MILLI AMPERE
VOLTAGE	24V DC
INGRESS PROTECTION	IP 67
OPERATING CURRENT	16 MILLI AMPERE
MOUNTING HOLE	22-22.5 MM
OPERATING TEMPERATURE	-25 TO + 60 CELCIUS
SERVICE LIFE	100 000 HOURS AT 25ºC
LUMINOUS INTENSITY	
A INDOOR	200MCD
B OUTDOOR	400 MCD

ITEM	COLOUR OF THE BUTTON	COLOUR OF THE FRAME (IF APPLICABLE)	ADDITIONAL FUNCTIONALITY OR DESCRIPTION	AS APPLICABLE ON: MOTORS	VALVES	CIRCUIT BREAKERS AND ISOLATORS	POWER SUPPLY INDICATION	HYDRAULIC SYSTEMS	BATTERY CHARGER	OVERHEAD CRANES	OTHER APPLICATIONS
	CONTROL PANEL LIGHTS			CONTROL PANEL LIGHTS						CONTROL PANEL LIGHTS	
P 1	RED			STOPPED/ ROTOR STATIONARY	CLOSED	OPENED (NO Current can flow)	N/A	STOP	NOT CHARGING	STOPPED	STOPPED, STANDING, STATIONERY, NOT DOING WHAT IT WAS DESIGNED TO DO, ABNORMAL CONDITION
P 2	RED		FLASHING WITH OR WITHOUT AUDIBLE SIREN	START/CLOSE/OPEN COMMAMD HAS BEEN ISSUED BUT THE TIME DELAY BETWEEN THE COMMAND INSTRUCTION AND THE COMMAND ACTION HAS NOT YET LAPSED.							
P 3	GREEN			RUNNING	OPEN	CLOSED (CURRENT CAN FLOW)	N/A	START	CHARGING	N/A	MOVING, RUNNING, FLOWING, DOING WHAT IT WAS DESIGNED TO DO
P 4	BLUE			AVAILABLE	AVAILABLE	AVAILABLE MECHANISM READY FOR USE	AVAILABLE	AVAILABLE OIL PRESSURE IS CORRECT	AVAILABLE BATTERY FULL - NOT CHARGING)	AVAILABLE	AVAILABLE, READY FOR USE, FULLY FUNCTIONAL, ALL INTERLOCKS READY
P 5	WHITE			TELEMETRY/ REMOTE CONTROL IS ACTIVE I.E.. CONTROL OF THE EQUIPMENT IS TO BE DONE VIA A REMOTE/TELEMETRY CONTROL THEREFORE THE. CONTROL PANEL IS IN-OPERATIVE							
P 6	YELLOW			TRIP ACKNOWLEDGED / ACCEPTED BUT NOT YET RESET / CLEARED / FIELD FAULT							TRIP ACCEPTED BUT THE CAUSE FOR THE TRIP HAS NOT YET BEEN CLEARED
P 7	YELLOW		FLASHING	N/A	VALVE MOVING BUT IN INTERMEDIATE POSITION	MV EQUIPMENT OPERATING SPRING BEING REWOUND	N/A		Not Applicable	Not Applicable	EQUIPMENT IN INTERMEDIATE POSITION: MOVING OR STATIONARY
P 8	YELLOW		NOT FLASHING	N/A	VALVE STATIONARY IN INTERMEDIATE POSITION		N/A				
P 9	YELLOW FLASHING		IN CONJUNCTION WITH A LIT GREEN LIGHT	1 ST LEVEL ALARM (eg HIGH TEMP, HIGH VIBRATION)	1 ST LEVEL ALARM	1 ST LEVEL ALARM TRANSFORMER TEMP, LOW SF6, LOW TRIPPING BATTERY VOLTGAGE ect.	N/A		1 ST LEVEL ALARM CHARGING CURRENT NOT TO SPECIFICATION	1 ST LEVEL ALARM	TAKE NOTE SITUATION IN WHICH THE ALARM SITUATION MIGHT STILL BE NEGATED
P 10	YELLOW FLASHING		IN CONJUCTION WITH A LIT RED LIGHT	TRIPPED	TRIPPED	TRIPPED	N/A		TRIPPED	TRIPPED	TRIPPED, NOT DOING WHAT IT WAS DESIGNED TO DO DUE TO A FAULT. TRIP NOT YET ACCEPTED
	CONTROL PANEL LIGHTS			CONTROL PANEL LIGHTS						CONTROL PANEL LIGHTS	

CONTROL PANEL LIGHTS

Department of Water Affairs - Colour Codes for Lights, Buttons and Switches - Version 1 - 6 September 2010

STROBE LIGHTS

TECHNICAL SPECIFICATION	
DESCRIPTION	REQUIREMENT
STROBE LIGHTS	
TYPE	XENON
NOMINAL FLASH RATE	DOUBLE HIT: 2 HERTZ
FLASH	DOUBLE : PRIMARY AND SECONDARY FLASH
LUMINIOUS INTENSITY	DOUBLE HIT 150 + 70cd
INGRESS PROTECTION	IP 65
OPERATING TEMPERATURE	-25 TO + 50 CELCIUS
SERVICE LIFE	>5 000 000 FLASHES

ITEM	COLOUR OF THE BUTTON	COLOUR OF THE FRAME (IF APPLICABLE)	ADDITIONAL FUNCTIONALITY OR DESCRIPTION	AS APPLICABLE ON: MOTORS	VALVES	CIRCUIT BREAKERS AND ISOLATORS	POWER SUPPLY INDICATION	HYDRAULIC SYSTEMS	BATTERY CHARGER	OVERHEAD CRANES	OTHER APPLICATIONS
	STROBE LIGHTS			STROBE LIGHTS							STROBE LIGHTS
L 1	RED FLASHING		WITH AUDIBLE SIREN	30 SECOND WARNING BEFORE STARTING	30 SECOND WARNING BEFORE OPENING	Not Applicable			Not Applicable		Warning to all persons at or near the equipment that the equipment is to be started. Can be overridden by activating the emergency stop.
L 2	YELLOW FLASHING		WITH AUDIBLE SIREN	TBA	TBA	TBA	TBA	TBA	TBA	EQUIPMENT IN MOTION	GENERAL WARING FOR EQUIPMENT IN MOLTION
L 3	GREEN FLASHING			TBA	TBA	TBA	TBA	TBA	TBA	TBA	
	STROBE LIGHTS			STROBE LIGHTS							STROBE LIGHTS

STROBE LIGHTS

Department of Water Affairs - Colour Codes for Lights, Buttons and Switches - Version 1 - 6 September 2010

TECHNICAL SPECIFICATION: DESCRIPTION	TECHNICAL SPECIFICATION: REQUIREMENT	ITEM	COLOUR: OF THE BUTTON	COLOUR: OF THE FRAME (IF APPLICABLE)	ADDITIONAL FUNCTIONALITY OR DESCRIPTION	AS APPLICABLE ON: MOTORS	VALVES	CIRCUIT BREAKERS AND ISOLATORS	POWER SUPPLY INDICATION	HYDRAULIC SYSTEMS	BATTERY CHARGER	OVERHEAD CRANES	OTHER APPLICATIONS
SCADA			SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD							SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD			
SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD	SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD	S 1	RED			STOPPED/ ROTOR STATIONARY	CLOSED	OPENED (NO Current can flow)		STOP	NOT CHARGING	STOPPED	STOPPED, STANDING, STATIONERY, NOT DOING WHAT IT WAS DESIGNED TO DO, ABNORMAL CONDITION
		S 2	RED		FLASHING WITH OR WITHOUT AUDIBLE SIREN	START/CLOSE/OPEN COMMAMD HAS BEEN ISSUED BUT THE TIME DELAY BETWEEN THE COMMAND INSTRUCTION AND THE COMMAND ACTION HAS NOT YET LAPSED.							
		S 3	GREEN			RUNNING	OPEN	CLOSED (CURRENT CAN FLOW)		START	CHARGING		MOVING, RUNNING, FLOWING, DOING WHAT IT WAS DESIGNED TO DO
		S 4	BLUE			AVAILABLE	AVAILABLE	AVAILABLE MECHANISM READY FOR USE	AVAILABLE	AVAILABLE OIL PRESSURE IS CORRECT	AVAILABLE BATTERY FULL - NOT CHARGING)	AVAILABLE	AVAILABLE, READY FOR USE, FULLY FUNCTIONAL, ALL INTERLOCKS READY
		S 5	WHITE			TELEMETRY/ REMOTE CONTROL IS ACTIVE I.E.. CONTROL OF THE EQUIPMENT IS TO BE DONE VIA A REMOTE/TELEMETRY CONTROL THEREFORE THE. CONTROL PANEL IS IN-OPERATIVE							
		S 6	YELLOW			TRIP ACKNOWLEDGED / ACCEPTED BUT NOT YET RESET / CLEARED / FIELD FAULT							TRIP ACCEPTED BUT THE CAUSE FOR THE TRIP HAS NOT YET BEEN CLEARED
		S 7	YELLOW		FLASHING		VALVE MOVING BUT IN INTERMEDIATE POSITION	MV EQUIPMENT OPERATING SPRING BEING REWOUND					EQUIPMENT IN INTERMEDIATE POSITION: MOVING OR STATIONARY
		S 8	YELLOW		NOT FLASHING		VALVE STATIONARY IN INTERMEDIATE POSITION						
		S 9	YELLOW FLASHING		IN CONJUNCTION WITH A LIT GREEN LIGHT	1 ST LEVEL ALARM (eg HIGH TEMP, HIGH VIBRATION)	1 ST LEVEL ALARM	1 ST LEVEL ALARM TRANSFORMER TEMP, LOW SF6, LOW TRIPPING BATTERY VOLTGAGE ect.			1 ST LEVEL ALARM CHARGING CURRENT NOT TO SPECIFICATION	1 ST LEVEL ALARM	TAKE NOTE SITUATION IN WHICH THE ALARM SITUATION MIGHT STILL BE NEGATED
		S 10	YELLOW FLASHING		IN CONJUCTION WITH A LIT RED LIGHT	TRIPPED	TRIPPED	TRIPPED			TRIPPED	TRIPPED	TRIPPED, NOT DOING WHAT IT WAS DESIGNED TO DO DUE TO A FAULT. TRIP NOT YET ACCEPTED
			SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD								SCADA COLOURING TO MATCH PANEL LIGHTS STANDARD		
			SCADA SPECIFIC COLOURING					SCADA SPECIFIC COLOURING				SCADA SPECIFIC COLOURING	
SCADA SPECIFIC COLOURING		S 11	BROWN			FAULT ON							MCC FAULT
		S 12	GRAY 25%			MAINTENANCE LOCK-OUT							MAINTENANCE
		S 13	DARK RED			TRIP ON MCC							TRIP ON MCC
		S 14	TURQUOISE			TRIP ON DRIVE INTERLOCK							TRIP ON DRIVE INTERLOCK
		S 15	VIOLET			TRIP ON RUN INTERLOCK							TRIP ON RUN INTERLOCK
		S 16	TEAL	FRAMED IN WHITE		SELECT / DESELECT							SELECT/DESELECT
		S 17	PINK	FRAMED IN WHITE		START INTERLOCK ACTIVE							START INTERLOCK
		S 18	ORANGE	FRAMED IN WHITE		SEQUENCE INTERLOCK ACTIVE							SEQUENCE INTERLOCK
		S 19	VIOLET	FRAMED IN WHITE		RUN INTERLOCK ACTIVE							RUN INTERLOCK
		S 20	TURQUOISE	FRAMED IN WHITE		DRIVE INTERLOCK ACTIVE							OPEN INTERLOCKS
		S 21`	LIGHT ORANGE	FRAMED IN WHITE		CLOSE INTERLOCK ACTIVE							CLOSE INTERLOCKS
		S 22											
			SCADA SPECIFIC COLOURING				SCADA SPECIFIC COLOURING				SCADA SPECIFIC COLOURING		

SCADA

Department of Water Affairs - Colour Codes for Lights, Buttons and Switches - Version 1 - 6 September 2010

(THE PRINCIPLE USED WAS THAT OF RED = STOP, AMBER = CAUTION and GREEN = GO)

RED = STOP (DOING NOTHING)	RED DENOTES STOP. IT INDICATES THAT EQUIPMENT IS STATIONARY, A VALVE IS CLOSED, A CIRCUIT BREAKER IS OPEN, A CRANE IS STATIONARY. (IT ACTS AS AS WARNING THAT ANY PERSONELL OR EQUIPMENT MIGHT BE IN A DANGEROUS POSITION AND THEREFORE COULD BE IN HARMS WAY)
GREEN = GO (WORKING)	GREEN INDICATES THAT THE EQUIPMENT IS DOING WHAT IT WAS DESIGNED TO DO. (A PUMP IS PUMPING, A VALVE IS RELEASING WATER IN A CONTROLLED MANNER, A CIRCUIT BREAKER IS CLOSED AND A CURRENT CAN FLOW, ETC.)
WHITE = INFORMATION TAKE NOTE OF	WHITE ACTS TO FOCUS ATTENTION ON CERTAIN INFORMATION. (THE PANEL IS IN REMOTE SETTING, THE PLC IS CONTROLLING THE PUMP SET, THE CIRCUIT BREAKER MECHANISM IS BEING WOUND, ETC)
YELLOW = ATTENTION (POSSIBLE PROBLEM)	YELLOW (OR IF UNAVAILABLE THEN AMBER) IS USED TO ATTRACT ATTENTION TO A PROBLEM THAT IS IN THE DEVELOPMENT STAGE OR HAS CAUSED A TRIP OR EMERGENCY STOP. (THE BEARING TEMPERATURE IS TO HIGH , MOTOR WINDING TEMPERATURE IS TOO HIGH, THE CHARGING CURRENT IS TO LOW ETC. SHOULD THE SITUATION NOT BE RECTIFIED A TRIP OR SHUT DOWN WILL OCCUR IN ORDER TO PROTECT THE EQUIPMENT/SYSTEM)
BLUE = AVAIALBLE (CAN DO)	BLUE ATS AS AN INDICATION THAT THE EQUIPMENT AS DESIGNATED IS READY FOR OPERATION. SHOULD THE GREEN PUSH BOTTOM BE ACTIVATED THE EQUIPMENT SHOULD DO WHAT IT WAS DESIGNED TO DO. (THE PUMP START SEQUENCE WILL START, A VALVE WILL START OPENING, A HYDRAULIC SYSTEM HAS ENOUGH PRESSURE TO OPERATE A CYLINDER ETC.)
ANY OTHER COLOUR	AS MAY BE NEEDED FOR A SPECIFIC APPLICATION AND IT IS NOT COVERED BY THE FIVE BASIC COLOURS AS MENTIONED ABOVE

aurecon

Engineering Standard

LV Switchgear & Controlgear Assemblies

25 June 2015

Revision: 0

Reference: EE-0010

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000

South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.

b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						aurecon
Specification title		LV Switchgear & Controlgear Assemblies				
Document ID		EE-0010	**Reference number**		EE-0010	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	E Biesenbach	M Hendricks	O Fair
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Ewald Biesenbach	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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 m^2 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 $\leq$ 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.

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:

a) voltage between phases and between phases and neutral

b) current in each phase

c) power (kW)

d) kVA

e) power factor

f) 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.

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 tappings.

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.

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 mm^2 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.

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 mm^2, 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 mm^2.

8.2.2 The following shall be directly connected to the compartment earthing terminal by earthing conductors with a minimum cross sectional of 4 mm^2 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:

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 mm^2 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 mm^2 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 mm^2 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.

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.

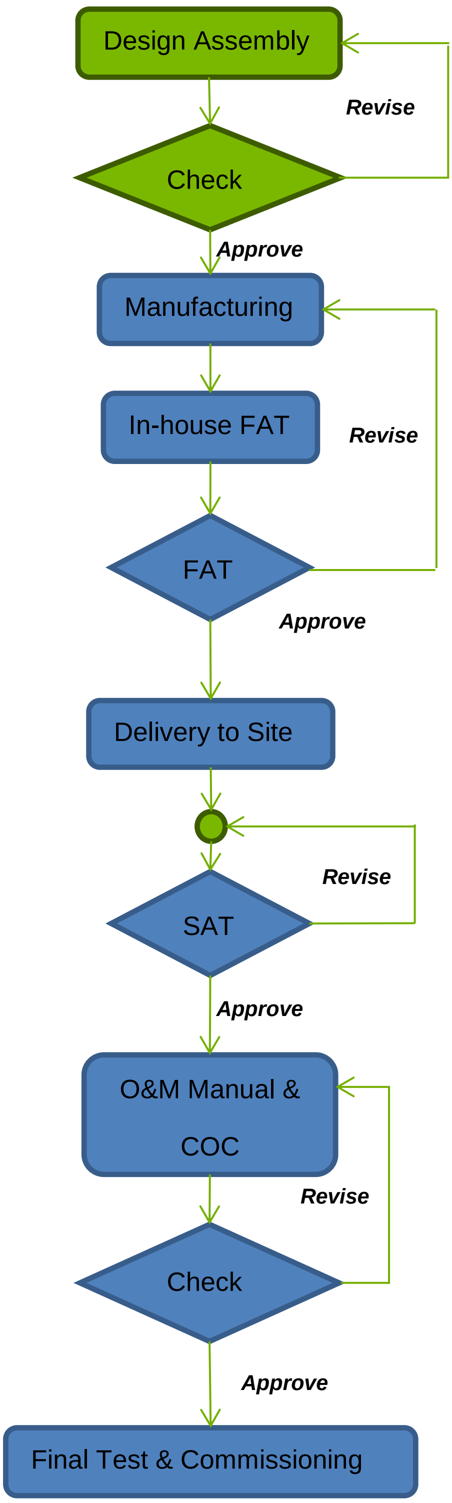
16.1.6 The manufacturer shall ensure that all testing is carried out in a safe manner, and shall protect those witnessing from danger; in accordance with the Occupational Health and Safety Act.

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
Manufacturer/Contractor	
Engineer	SLD drawings, Assembly GA drawings
Manufacturer/Contractor	
Manufacturer/Contractor	In-house FAT document
Manufacturer/Contractor/ Engineer/ Client (If required)	Final FAT document, Functional Specification
Manufacturer/Contractor	
Manufacturer/Contractor /Engineer	SAT document
Contractor to provide to Engineer	Draft Copy of O&M manual COC
Engineer Contractor provides O&M Manuals	3 Copies of approved O&M manual
Manufacturer/Contractor /Engineer/Client(If required	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.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Low Voltage Cables

25 June 2015

Revision: 0

Reference: EE-0011

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:
a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control							aurecon
Specification title		Low Voltage Cables					
Document ID		EE-0011		**Reference number**		EE-0011	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**	
0	25 June 2015	First Issue	M Kriel	E Biesenbach	C Reeder	O Fair	
Current revision		**0**					

Approval			
Author signature		**Approver signature**	
Name	Ewald Biesenbach	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Electrical Engineer

Contents

Tables

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 mm^2 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 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

a) The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.

b) 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, lose 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 ouklip, 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) 45º, when all cables have a diameter less than 35 mm; or

ii) 22.5º, 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 5º 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:

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Cable Support Systems

25 June 2015
Revision: 0
Reference EE-0012

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						
Specification title	Cable Support Systems					
Document ID	EE-0012		**Reference number**	EE-0012		
File path	N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	E Biesenbach	C Reeder	O Fair
Current revision	0					

Approval			
Author signature		**Approver signature**	
Name	Ewald Biesenbach	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000

South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Wiring and Outlets

25 June 2015

Revision: 0

Reference: EE-0013

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control							aurecon
Specification title		Wiring and Outlets					
Document ID		EE-0013	**Reference number**		EE-0013		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**	
0	25 June 2015	First issue	M Kriel	C Reeder	E Biesenbach	O Fair	
Current revision		**0**					

Approval			
Author signature		**Approver signature**	
Name	Christo Reeder	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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 to19/22kV (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(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. 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

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

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 rewireable.

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

a) 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.

b) 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.

c) 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

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Lighting

25 June 2015

Revision: 0

Reference: EE-0014

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000

South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						
Specification title	Lighting					
Document ID	EE-0014		**Reference number**	EE-0014		
File path	N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	C Reeder	E Biesenbach	O Fair
Current revision	**0**					

Approval			
Author signature		**Approver signature**	
Name	Christo Reeder	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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 to19/22 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(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. 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

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

aurecon

Engineering Standard

MV & LV Earthing

25 June 2015

Revision: 0

Reference: EE-0020

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title		MV & LV Earthing				
Document ID		EE-0020	**Reference number**	EE-0020		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	M Hendricks	E Biesenbach	O Fair
Current revision		0				

Approval			
Author signature		**Approver signature**	
Name	Mike Hendricks	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

Figures

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 mm^2 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-subs (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 mm^2 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 mm^2 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-actylene 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 (ETSs) for lightning protection systems (LPSs) 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:

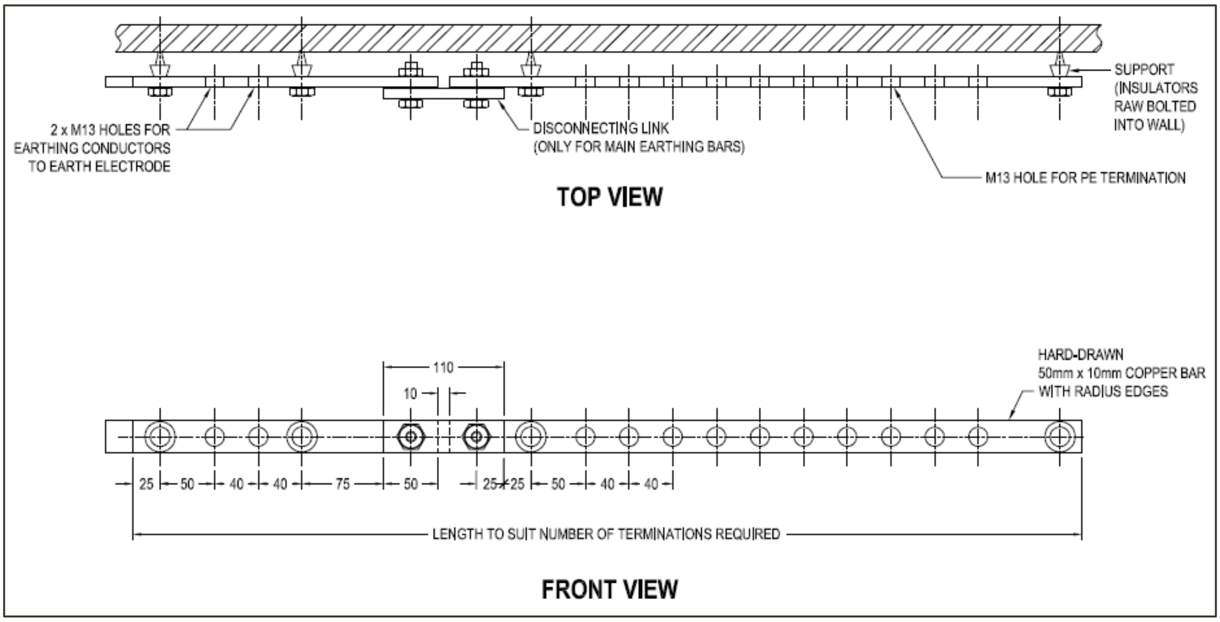


Figure 1: Earthing Bar

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 earth 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:

a) With supply cables to MV switchgear and to LV Assemblies

b) 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-subs, 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):

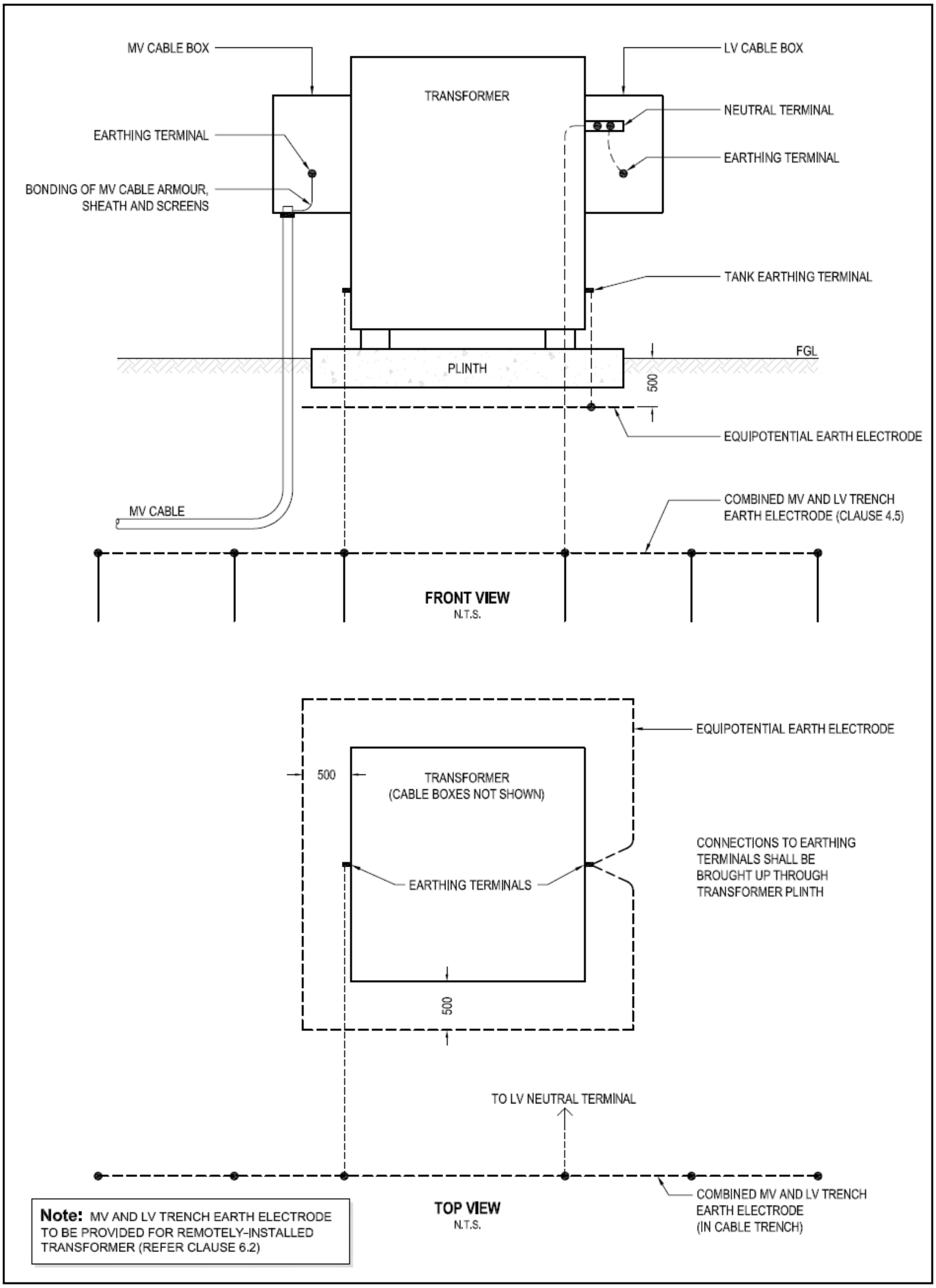
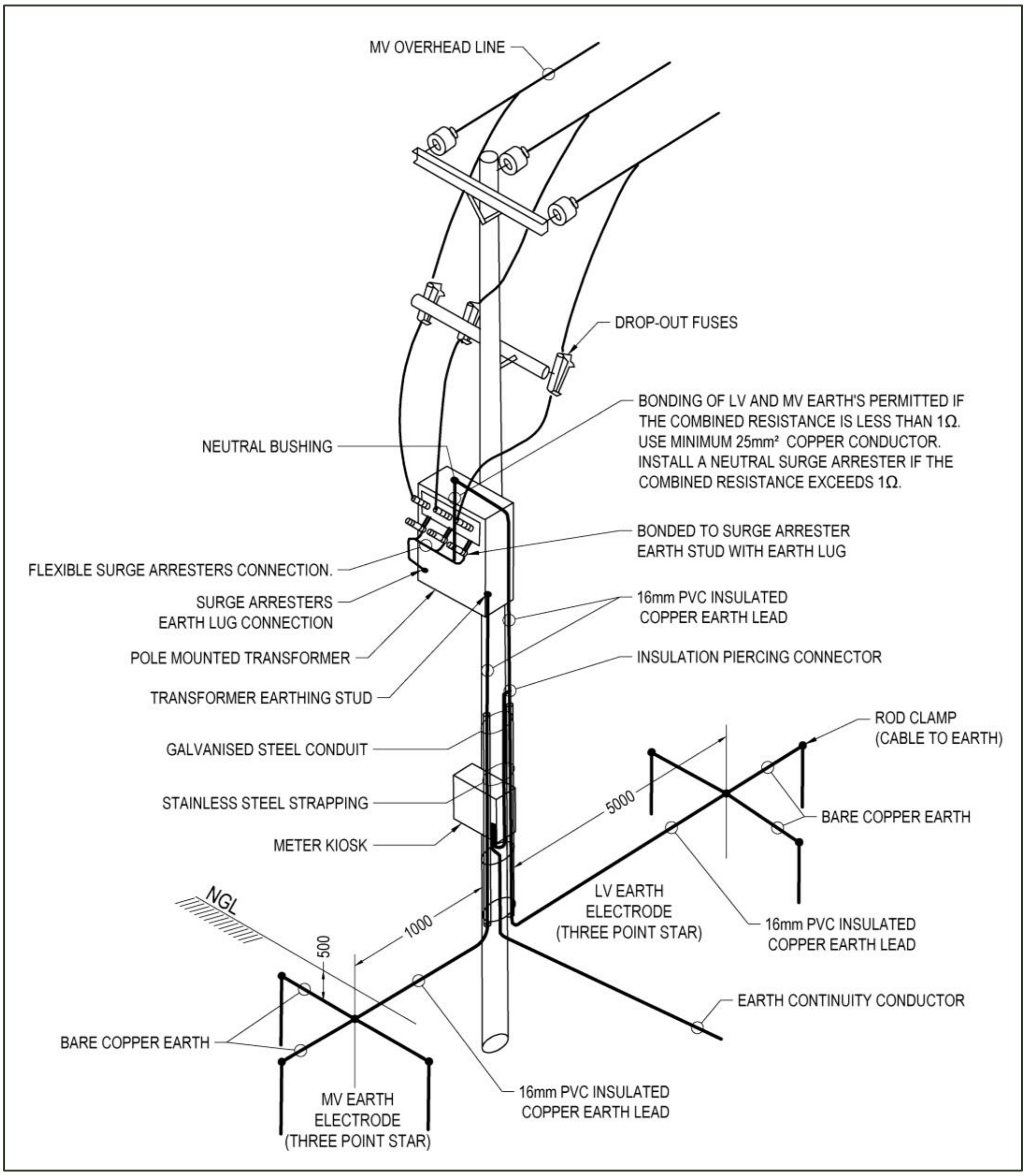


Figure 2: Distribution Transformer Earthing

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 ARRESTORS ARE TO BE BONDED AND CONNECTED TO THE MV EARTH ELECTRODE.
2. THE TRANSFORMER NEUTRAL, LV SURGE ARRESTORS 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.

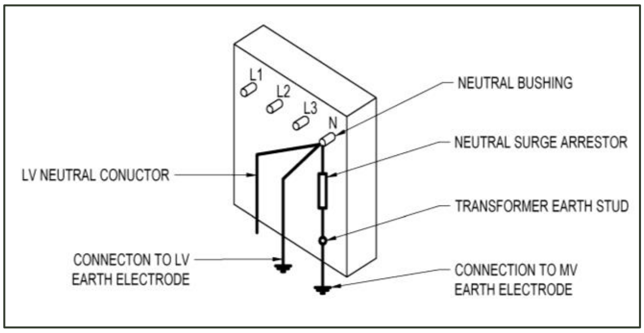


Figure 3: Earthing at MV/LV transformer pole mounted transformer

6.3 Miniature Substations (Mini-subs)

6.3.1 Mini-subs 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-subs 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-subs (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.

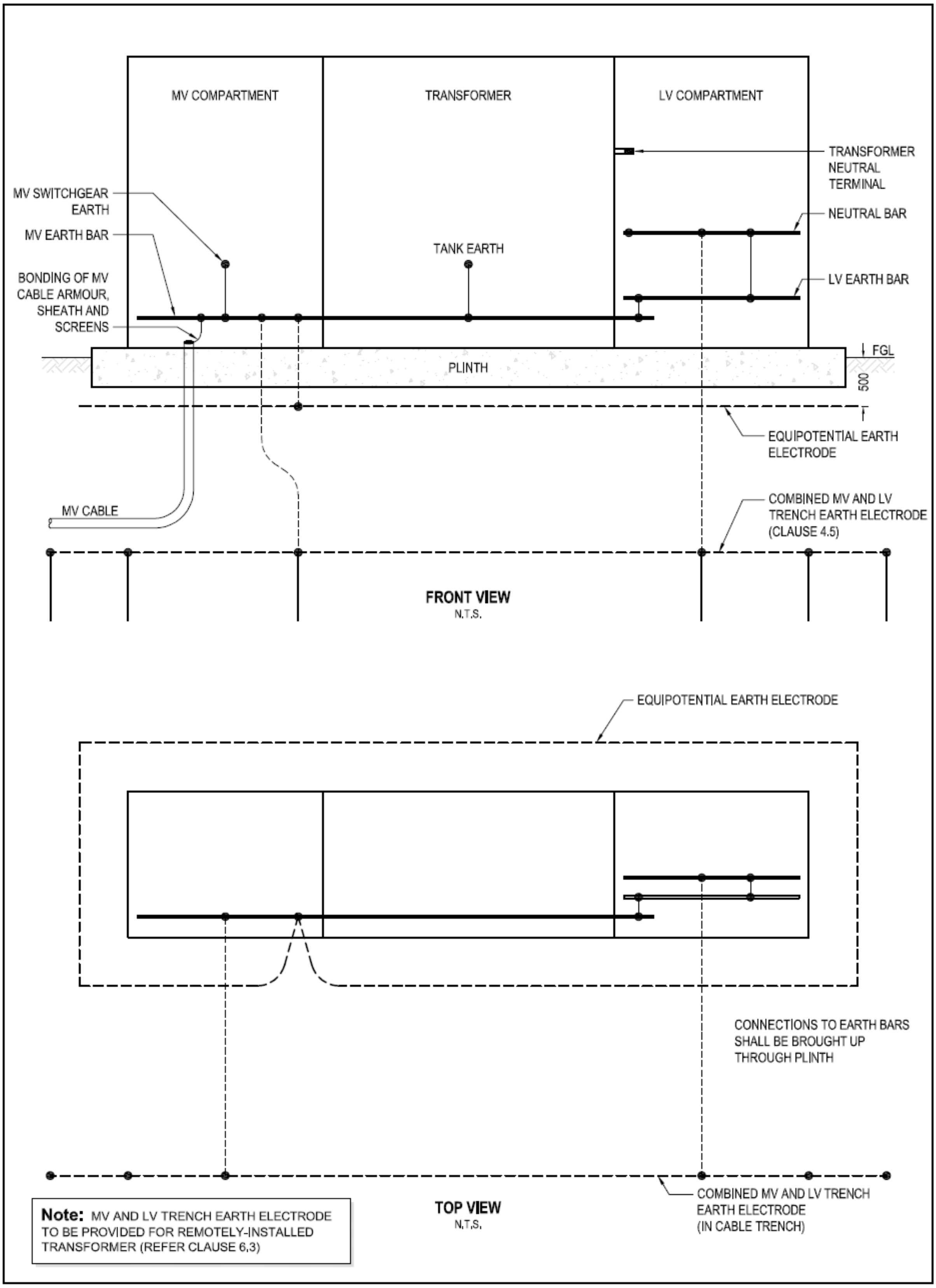


Figure 4: Mini Sub Earthing

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.

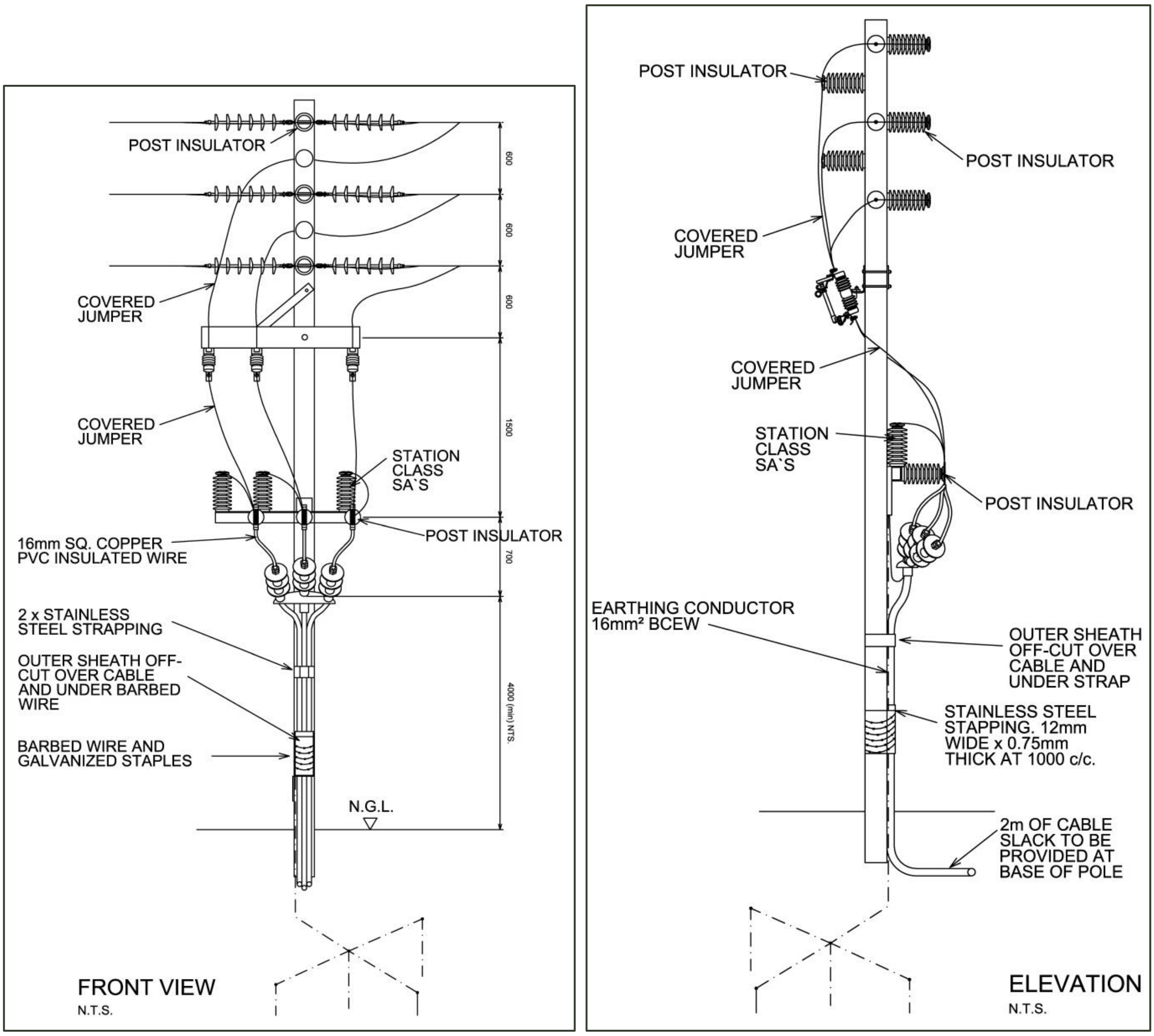


Figure 5: Earthing of MV Overhead Surge Arresters

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.

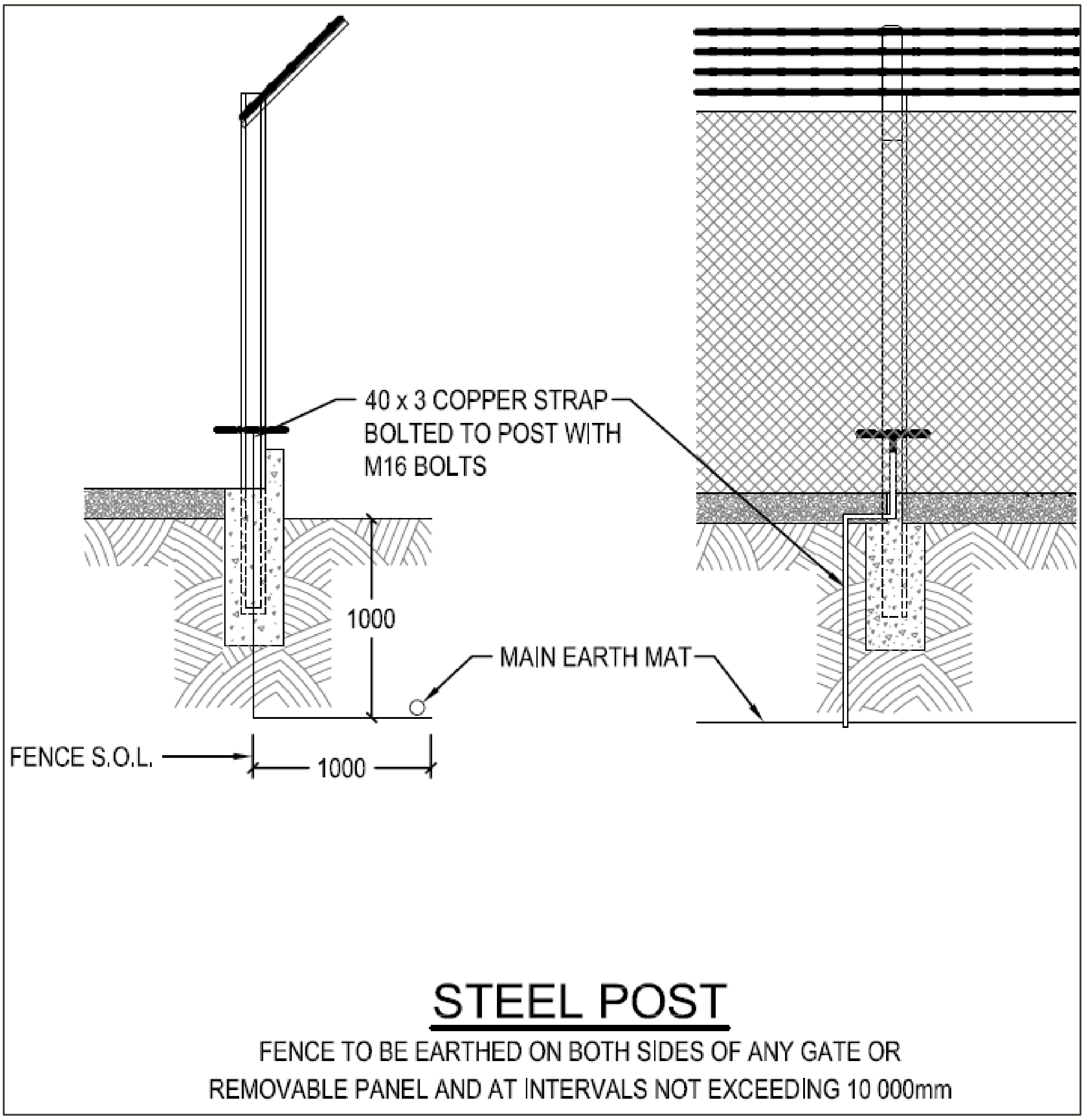
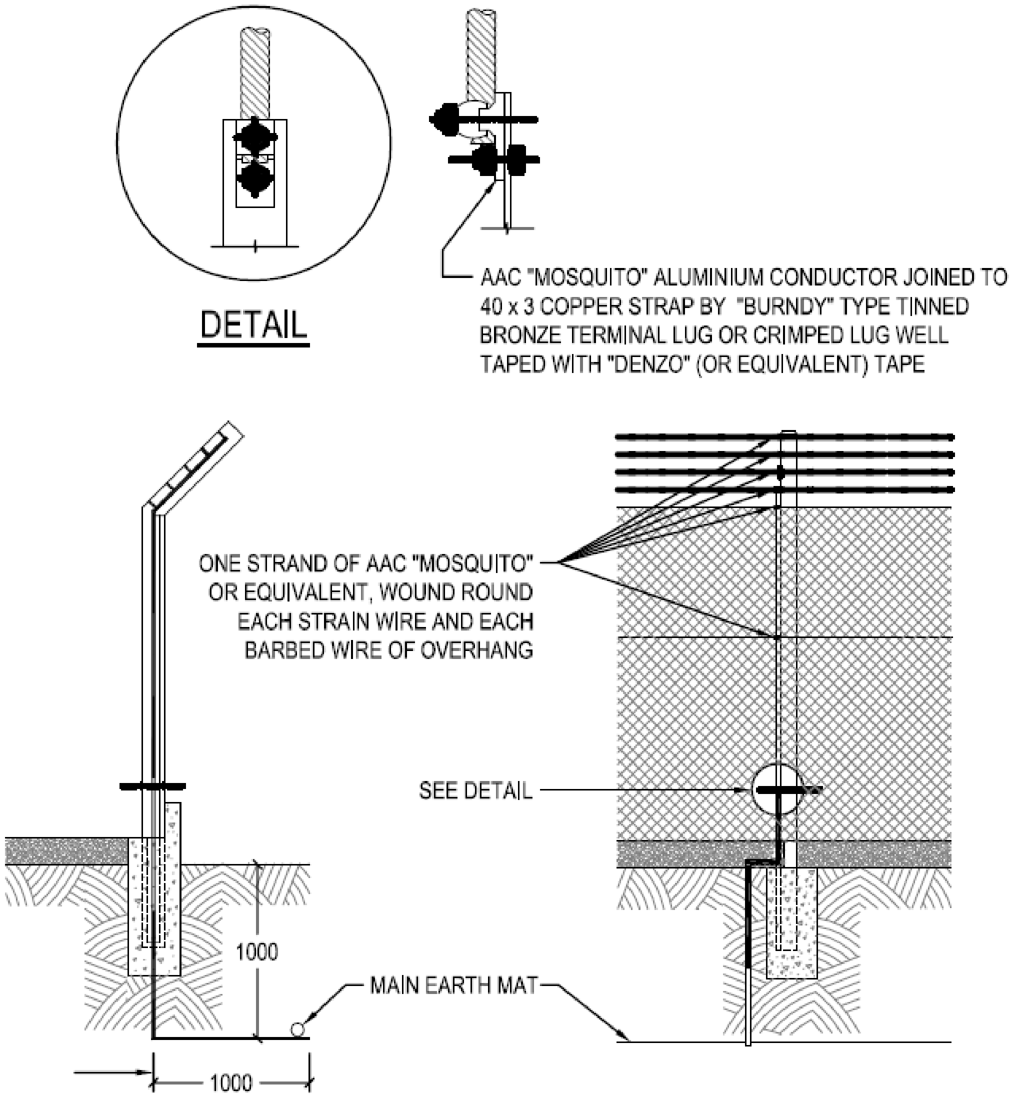


Figure 6: Earthing of Equipment Yard Fences



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.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Lightning Protection for Structures

25 June 2015

Revision: 0

Reference: EE-0021

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						
Specification title	Lightning Protection for Structures					
Document ID	EE-0021		**Reference number**	EE-0021		
File path	N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	M Hendricks	E Biesenbach	O Fair
Current revision	0					

Approval			
Author signature	MHendricks	**Approver signature**	
Name	Mike Hendricks	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This Standard Specification covers the materials, components and installation requirements for lightning protection systems for structures to provide protection measures to reduce:

a) Injury of living beings by electric shock

b) Physical damage to structures to be protected

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 external and internal lightning protection systems as defined in SANS 62305, but does not cover surge protection measures for the protection of electrical and electronic systems against lightning electromagnetic impulses.

1.1.4 This standard specification does not cover the earth termination system for lightning protection, which is covered by Engineering Standard SPE-EE-0020 - "MV & LV Earthing", and which shall be read in conjunction with this standard specification.

1.2 General Requirements

1.2.1 The completed lightning protection installation shall incorporate all materials and components necessary to provide the required lightning protection systems.

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.

1.2.3 The lightning protection system shall achieve the class and hence protection level specified in the Project Specification.

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 lightning protection systems shall comply with all relevant statutory regulations, and the latest editions (current at the time of tender) of all referenced South African National Standards.

2.2 Statutory Requirements

2.2.1 The lightning protection systems shall comply with the following:

a) SANS 10142-1 The Wiring of Premises Part 1: Low-voltage Installations

b) 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 10313	Protection against lightning - Physical damage to structures and life hazard
SANS 61643	Low-voltage surge protective devices
SANS 62305-3	Protection against lightning Part 3: Physical damage to structures and life hazard
SANS 62305-4	Protection against lightning Part 4: Electrical and electronic systems within structures
SANS 62561	Lightning protection system components

3. MATERIALS

3.1 Selection of Materials

3.1.1 Materials, configurations, cross-sectional area and recommended dimensions for air termination conductors and rods, down conductors and earth lead-in rods shall be in accordance with Table 1 of SANS 62561-2.

3.1.2 Material shall be selected to avoid corrosion of either the structure to be protected or of the lightning protection system. A conductor material shall therefore be selected that is compatible with the surface it is to be located on and that which it is to be connected to. For guidance in this regard, refer to Table 5 of SANS 62305-3.

3.1.3 Galvanic corrosion between two dissimilar metals in contact with each other shall be avoided, and combinations of metals with electrochemical potential differences exceeding 0,35 V are not permitted.

3.1.4 Tin-plated copper conductors may be connected to aluminium, steel, grey cast iron, cadmium and lead. Tin plating is not required for connections to stainless steel, tin or bronze.

3.1.5 Aluminium conductors may be connected to steel (including galvanized and stainless), cast iron, tin and zinc. Aluminium and copper are not compatible and bimetallic connectors shall be used to interconnect these two materials.

3.1.6 The aesthetics of longer term white corrosion of aluminium and green verdigris of copper shall be considered and PVC covering provided where specified in the Project Specification.

3.1.7 Materials and components shall comply with the requirements of SANS 62561 as applicable.

3.2 Installation and Fixing of materials

3.2.1 Aluminium shall not be installed in direct contact with plaster, cement, mortar, limestone or surfaces coated with alkaline-based paints. Stand-off fixings or PVC-covered aluminium shall be used in these contact situations.

3.2.2 Being proned to corrosion in marine environments, the aluminium in coastal environments shall be avoided. It shall also not be installed in locations where water may accumulate (e.g. in gutters or in locations where water may be retained) or where it will be exposed to water run-off from copper or copper alloy surfaces. PVC-covered aluminium may be provided with the Engineer’s approval for these applications, except where part of the air termination system.

3.2.3 Copper shall not be installed where exposed to sulphurous atmospheres or above galvanized, zinc or aluminium parts where water run-off occurs. Copper shall also not be installed where there is a risk of theft.

3.2.4 Fasteners and connectors shall comply with the requirements of SANS 62561 as applicable.

3.2.5 Aluminium shall not be buried in the ground.

4. AIR-TERMINATION SYSTEMS

4.1 Metal Roofs

4.1.1 Air-termination systems shall only be provided on metal roofs if specified in the Project Specification, otherwise the metal roof and its metal support structure shall serve as a natural air-termination system.

4.1.2 If an air-termination system shall be installed (i.e. it is specified in the Project Specification because the thickness of the metal roof sheets does not meet the requirements of SANS 62305-3 and/or it is important to prevent puncture or hot spots), the air-termination system shall comply with the requirements of Sub-clause 4.2 below, except that fixing holes may not be drilled into metal roofs.

4.1.3 Where the metal roof and its metal support will serve as a natural air termination system, the lighting protection installer shall check that the roof and its support structure are electrically continuous. If supplementary electrical connections are required, the lightning protection installer shall submit a proposal for adding bridging braids/conductors to the Engineer for approval.

4.2 Non-Metal Roofs

4.2.1 An air-termination system comprising conductors and rods shall be provided on structures as specified in the Project Specification.

4.2.2 Edge conductors shall be installed as close to the roof edges to be protected as practicable, but preferably be out of sight from ground level to avoid theft.

4.2.3 Fixing and connecting components shall be proprietary items which comply with SANS 62561. The spacing of these components shall be in accordance with the manufacturer's specification.

4.2.4 Conductor holders shall be a combination of clamping and non-clamping type as appropriate to allow for conductor expansion/contraction.

4.2.5 Air-termination rods shall be mounted so as to withstand wind loading stresses. Rods along the roof edge shall be located not more than half the rod height from the edge.

4.2.6 Conductive rooftop fixtures shall be protected by the air-termination system, or bonded to it, or located a suitable separation distance from it. However, none of the aforementioned measures needs to be taken if the dimensions of a fixture do not exceed all of the following values:

a) Height above the roof level 0,3 m

b) Total area of the fixture 1,0 m²

c) Length of the fixture 2,0 m

4.3 Preferred Materials

4.3.1 Air-termination conductors shall be at least 50 mm² (8 mm diameter) solid round aluminium or alternative as approved by the Engineer.

4.3.2 Unless otherwise specified in the Project Specification, air-termination rods shall be 15 mm diameter, 500 mm high, aluminium/aluminium alloy rods or alternative as approved by the Engineer.

5. DOWN-CONDUCTOR SYSTEMS

5.1 Natural Components

5.1.1 Reinforcing steel (rebars) in the concrete columns of new structures shall be used as natural down-conductors when specified in the Project Specification.

5.1.2 Specific rebars in the main structural columns shall be selected as down-conductors and the lightning protection installer shall check that these are electrically continuous from top to bottom with a resistance of not more than 0,2 ohm. A 4-pole resistance measuring device shall be used for this purpose to eliminate the effect of instrument lead resistance. Proof of the measurement shall be submitted to the Engineer.

5.1.3 The upper connection (for air-termination system to down-conductor connection) shall be made with two clamps to two separate rebars, and the lower connection (for down-conductor to earth termination system connection) shall be made with a single clamp. Exothermically-welded connections may be made in the place of clamps.

5.1.4 The above-mentioned connections shall be brought out to terminals on the face of the column to provide points for bolted connections of the air-termination system and earth termination system respectively to the down-conductor (rebar).

5.1.5 The lightning protection installer shall arrange and carry out joint inspections with the building Contractor to check that planned rebar interconnections and the upper and lower connections have been properly made before concrete pours.

5.1.6 Steel columns shall be used as natural down-conductors when specified in the Project Specification. Connections from the columns to the air termination system and to the earth termination system shall be bolted connections which shall be pre-approved by the Engineer before cast in concrete or bricked up.

5.2 Dedicated Down-Conductors

5.2.1 Dedicated down-conductors shall be provided as specified in the Project Specification where natural components cannot be used for this purpose.

5.2.2 The routing of a down-conductor shall be straight and vertical to provide the shortest and most direct path, and loops shall be avoided unless the requirements for separation distances in SANS 62305-3 can be met.

5.2.3 Fixing and connecting components shall be proprietary items which comply with SANS 62561. The spacing of these components shall be in accordance with the manufacturer's specification.

5.2.4 Conductor holders shall be a combination of clamping and non-clamping type as appropriate to allow for conductor expansion/contraction.

5.2.5 The lower end of each down-conductor shall terminate at a test joint from which the final connection to the earth termination system shall be made. It shall only be possible to open the test joint with the aid of a tool for the purposes of taking electrical measurements. Test joints shall be numbered by permanent means and the numbers recorded on the as-built drawings.

5.2.6 Where there is a potential hazard due to touch and step voltages in the vicinity of the down-conductors, protection measures shall be implemented as specified in the Project Specification or, if not specified, in accordance with SANS 62305-3 and subject to approval by the Engineer.

5.3 Preferred Materials

5.3.1 Dedicated down-conductors shall be 50 mm² (8 mm diameter) solid round aluminium or alternative as approved by the Engineer.

5.3.2 Connections to rebars shall be made with 50 mm² stranded copper conductor.

6. EARTH TERMINATION SYSTEM

6.1 General

6.1.1 The earth termination system shall be provided in accordance with the Project Specification and Engineering Standard SPE-EE-0020 - "MV & LV Earthing".

6.1.2 For structures requiring a Type A earth termination system, it shall be utilized for lightning protection only. For structures requiring a Type B earth termination system, it shall serve as a multi-purpose earth electrode. (Type A and Type B arrangements are defined in SANS 62305-3.)

6.2 Connections to Earth Electrodes

6.2.1 Earth lead-in rods shall be provided to connect down-conductors to earth electrodes when specified in the Project Specification. Earth lead-in rods shall comply with the requirements of SANS 62561-2 and shall be fixed to the structure to provide a mechanically stable connection to the earth electrode.

6.2.2 Connections from terminals that are connected to rebars in concrete columns (refer 5.1.3) to earth electrodes shall be made with PVC-insulated stranded copper conductor. The conductor shall be run in galvanised steel conduit from just below the terminal to 300 mm below finished ground level.

6.2.3 Connections from steel columns to earth electrodes shall be made with PVC-insulated stranded copper conductor. The connection to the column shall be a bolted connection to the base plate of the column and shall be pre-approved by the Engineer.

6.2.4 Connections of the PVC-insulated stranded copper conductor to earth lead-in rods and earth electrodes shall be of the exothermically-welded type.

6.3 Preferred Materials

6.3.1 Earth lead-in rods shall be solid round 16 mm diameter stainless steel and of a suitable length to reach from a down-conductor test joint to 300 mm below finished ground level.

6.3.2 PVC-insulated copper conductor shall be 50 mm^2 unless otherwise specified in the Project Specification

7. INTERNAL LIGHTNING PROTECTION SYSTEM

7.1 General

7.1.1 Dangerous sparking between the lightning protection system and metal installations, external conductive parts, internal systems, and electrical lines connected to the structure to be protected, shall be avoided by means of equipotential bonding.

7.1.2 Main earthing bars provided as part of earth termination systems shall also serve as bonding bars for lightning equipotential bonding unless otherwise specified in the Project Specification.

7.1.3 Where dedicated lightning equipotential bonding bars shall be provided, these shall be connected to the main earthing bars with stranded bare copper conductors with a minimum cross-section of 16 mm^2.

7.2 Lightning Equipotential Bonding

7.2.1 Lightning equipotential bonding shall be provided for external conductive parts (e.g. metallic pipes) at the point of entry into the structure to be protected by means of bare stranded copper conductors sized to withstand the part of the lightning current calculated to flow through them. If direct bonding is not acceptable, bonding shall be via isolating spark gaps as specified in the Project Specification.

7.2.2 Lightning equipotential bonding shall be provided for internal metal installations (where these are not already bonded to the main earthing bars for electrical protection/safety reasons) by means of 6 mm^2 bare stranded copper conductors. This shall include but not be limited to electric cable supports, rails in lift shafts, air ducts, water pipes and gas pipes.

7.2.3 The bonding of internal system cables and the provision of surge protection devices will form part of the provision of the internal services.

7.2.4 The bonding of electrical lines connected to the structure to be protected and the provision of surge protection devices will form part of the provision of the connections.

8. INSPECTION AND TESTING

8.1 Testing

8.1.1 Where steel reinforcing in concrete columns is used as natural down-conductors, the electrical continuity shall be checked by way of a resistance measurement as specified in Clause 5.1.2.

8.1.2 The earth resistance of the earth electrode shall be measured as part of the scope of work for the earth termination system which is separately specified.

8.1.3 All lightning protection system earthing and equipotential bonding connections shall be subjected to continuity testing.

8.2 Inspection

8.2.1 The complete lightning protection system shall be inspected in accordance with the checklist in SANS 62305-3.

9. DOCUMENTATION

9.1 General

9.1.1 All 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 number

c) Engineer's name and contact details

d) Engineer's reference number

e) Contractor's works / contract / order references

f) Contractor's name and contact details

9.1.2 Drawings shall be provided on A1 or A3 paper copies as specified.

9.2 Drawings for Acceptance by the Engineer

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

9.3 Inspection and Testing Documentation and Reports

9.3.1 Records of all inspections and tests shall be submitted to the Engineer for acceptance before taking over of the works.

9.3.2 An installation safety report shall be issued on completion of all inspections and testing as per the pro forma in Annex A of SANS 10313.

9.4 Operating and Maintenance Manual

9.4.1 As-built drawings, inspection and test reports, and the installation safety report shall be included in the Operating and Maintenance Manual which shall be provided under the Contract.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

MV and LV Power Factor Correction with Static Capacitors

25 June 2015

Revision: 0

Reference: EE-0022

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title		MV and LV Power Factor Correction with Static Capacitors				
Document ID		EE-0022	**Reference number**		EE-0022	
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	M Hendricks	E Biesenbach	O Fair
Current revision		**0**				

Approval			
Author signature	MHendricks	**Approver signature**	
Name	Mike Hendricks	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

TABLES

1. SCOPE

1.1 Application

1.1.1 This Standard Specification covers the provision of reactive power compensation for power factor correction (PFC) with static capacitors for low- and medium voltage systems (up to 33 kV).

1.1.2 Project-specific requirements are dealt with in the Project Specification, which shall be read in conjunction with this standard specification.

1.2 Electrical System Characteristics

1.2.1 The operating characteristics of the electrical systems and plant, which the PFC equipment shall connect to, are specified in the Project Specification.

1.3 Installation Performance Requirements

1.3.1 The PFC equipment shall be suitable for:

a) Its intended duty with respect to the electrical supply, distribution system, and load requirements;

b) The environmental conditions, particularly with respect to corrosion resistance and ingress protection;

c) Its intended location, particularly with respect to the mechanical properties and impact strength of the components.

1.3.2 The PFC equipment shall be compatible with existing equipment, plant, machinery and services to which it will be connected.

1.3.3 The PFC equipment shall satisfy the specified operational and functional requirements and be readily and easily maintained throughout its operating life.

2. STANDARDS

2.1 Statutory Requirements

2.1.1 The PFC equipment/installation shall comply with the following:

a) Occupational Health and Safety Act 85 of 1993 and Regulations

b) SANS 10142 The Wiring of Premises Parts 1 and 2

2.2 Reference Standards

2.2.1 The following national and international standards shall be complied with as applicable:

Table 1: Reference Standards

Standard Number	Description
SANS 61869	Instrument transformers
SANS 60076-6	Power transformers - Reactors
SANS 61558-2-20	Safety of transformers, reactors, power supply units and combinations thereof - Part 2-20: Particular requirements and tests for small reactors
SANS 62271-1	High-voltage switchgear and controlgear: Part 1: Common specifications
SANS 62271-106	High-voltage switchgear and controlgear: Part 106: Alternating current contactors, contactor-based controllers and motor-starters
Other Standards	**Description**
IEC 60549	High-voltage fuses for the external protection of shunt power capacitors.
IEC 60831-1	Shunt power capacitors of the self-healing type for a.c. systems having a rated voltage up to and including 1000 V - Part 1: General
IEC 60871-1	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General.
IEC 60871-4	Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 4: Internal fuses.
SPE-EP-0002	Aurecon Engineering Specification: Indoor MV (metal-enclosed) switchgear
SPE-EE-0010	Aurecon Engineering Specification: LV switchgear and controlgear assemblies
SPE-EE-0020	Aurecon Engineering Specification: MV and LV earthing

3. CAPACITORS

3.1 General

3.1.1 Shunt-connected capacitors shall be used to provide reactive compensation for power factor correction (PFC).

3.1.2 The capacitors shall be connected in one of the following ways as specified in the Project Specification:

a) On a distributed basis to serve individual loads,

b) On a group basis to serve one or more groups of loads,

c) On a centralized basis to serve an entire electrical installation,

d) A combination of the above.

3.1.3 Unless otherwise stated in the Project Specification, capacitor ratings given in the Project Specification are indicative only, and actual required ratings shall be determined by Tenderers and the Contractor to suit offered and final plant ratings respectively.

3.1.4 When the actual required capacitor output (reactive power) is specified in the Project Specification, it shall be taken to be the rated output after adjustment for operating voltage (versus rated voltage) and the reactive power drawn by series reactors.

3.1.5 Capacitors shall be connected to provide either fixed or automatically-controlled PFC as specified in the Project Specification.

3.2 MV Capacitors

3.2.1 Capacitor units and banks shall comply with IEC 60871-1 as amended by this standard specification and the Project Specification.

3.2.2 Banks shall comprise the required number of identical three-phase units or single-phase units connected in a single- or double star arrangement as appropriate.

3.2.3 Capacitor elements shall be made with all polypropylene film dielectric. The impregnation liquid shall be biodegradable and shall not contain any polychlorinated biphenyls (PCBs) or any derivatives. Only non-toxic gas may be given off on combustion.

3.2.4 Capacitor units shall be protected against individual element failure by the use of internal fuses with adequate interrupting capacity. The fuses shall remove a failed element from the circuit without tank rupture. The internal fuses of capacitor units shall comply with IEC 60871 Part 4.

3.2.5 Each capacitor unit shall be fitted with an internally-mounted electrical discharge device as required by IEC 60871-1.

3.2.6 The container of the capacitor unit shall be constructed from a high grade hermetically sealed minimum 304 stainless steel. The wall thickness of the container shall be selected to ensure that the capacitor is capable of withstanding the maximum stress likely to be encountered under any service circumstances.

3.2.7 The bushings of the capacitor units shall be of the weld-sealed porcelain type. Insulation levels shall be as specified in the Project Specification and the nominal creepage distance shall be 25 mm/kV unless otherwise specified in the Project Specification. The capacitor bushing terminals shall be protected by insulating covers covering all live metal hardware.

3.2.8 Unless increased levels are specified in the Project Specification, capacitors shall be rated to operate continuously at 110 % of the system rated r.m.s. voltage and to carry a continuous r.m.s. current of 130 % of the rated current at system rated voltage and frequency.

3.2.9 Capacitor banks shall be designed so that there is sufficient heat dissipation at full rating and at the specified ambient temperature to ensure that unit temperatures are within acceptable limits.

3.2.10 Total capacitor unit loses (including discharge resistor and internal fuses) shall be less than 0.5 W/kVAr, of which the dielectric losses shall not exceed 0,2 W/kVAr. Loss calculations for capacitor banks shall include series reactors, external fuses and connections.

3.2.11 Support frames for capacitors shall be made of hot-dipped galvanized steel.

3.3 LV Capacitors

3.3.1 Capacitor units and banks shall comply with IEC 60831-1 as amended by this standard specification and the Project Specification.

3.3.2 Capacitor banks shall comprise the required number of identical three-phase units connected in parallel to operate as a unit.

3.3.3 Capacitor elements shall be made with self-healing, metallized polypropylene film. The units shall be dry-type with no impregnation liquid.

3.3.4 Capacitor units shall be protected against individual element failure by the use of internal fuses with adequate interrupting capacity. The fuses shall remove a failed element from the circuit without tank rupture.

3.3.5 Each capacitor unit shall be fitted with an internally-mounted electrical discharge device as required by IEC 60831-1.

3.3.6 The container of the capacitor unit shall be constructed from mild steel which shall be treated and painted for corrosion protection. Cylindrical capacitor units shall be in aluminium enclosures. Capacitor units for installation inside LV Assemblies shall have an IP42 rating, and indoor exposed units for installation outside of electrical rooms shall have an IP54 rating.

3.3.7 Unless increased levels are specified in the Project Specification, capacitors shall be rated to operate continuously at 110 % of the system rated r.m.s. voltage and to carry a continuous r.m.s. current of 130 % of the rated current at system rated voltage and frequency.

3.3.8 Capacitor banks shall be designed so that there is sufficient heat dissipation at full rating and at the specified ambient temperature to ensure that unit temperatures are within acceptable limits.

3.3.9 Total capacitor unit loses (including discharge resistor and internal fuses) shall be less than 0.4 W/kVAr, of which the dielectric losses shall not exceed 0,2 W/kVAr. Loss calculations for capacitor banks shall include series reactors, external fuses and connections.

4. REACTORS

4.1 General

4.1.1 Damping (inrush) reactors shall be provided in series with capacitor banks which are switched in parallel to limit inrush currents to acceptable levels.

4.1.2 Detuning (blocking) reactors shall be provided in series with capacitor banks where unacceptable resonance would occur with the supply system inductance at particular harmonic frequencies.

4.1.3 Reactors shall be fixed reactance, naturally-cooled, and of the indoor or outdoor type to suit the application.

4.1.4 Reactors with power ratings equal to or greater than 1 kVAr for single-phase and 5 kVAr for three-phase shall comply with SANS 60076-6. Smaller reactors shall comply with SANS 61558-2-20.

4.1.5 Design parameters for the reactors shall be as specified in the Project Specification.

4.2 Iron-core Reactors

4.2.1 Iron-core reactors may be used if their non-linear characteristics are acceptable for the application.

4.2.2 Iron-core reactors are preferred for use as detuning reactors for indoor installation.

4.2.3 Indoor reactors shall be of the dry type and shall either be installed inside enclosures housing the PFC capacitor banks, or in dedicated IP21 enclosures if installed separately.

4.2.4 Outdoor reactors shall be of the oil-immersed type with ONAN cooling. The reactor tank shall be of the sealed type.

4.2.5 Indoor reactors may be single- or three-phase units and outdoor reactors shall be three-phase units.

4.2.6 Dry type indoor reactors shall have either VPI windings or cast-resin encapsulated windings.

4.3 Air-core Reactors

4.3.1 Air-core reactors shall be of the single-phase, air-cooled, dry type, and are preferred for use as damping reactors for indoor installation. These reactors may be used as either damping or detuning reactors for outdoor installation.

4.3.2 Where practicable, indoor air-core reactors shall be installed inside enclosures housing the PFC capacitors.

4.3.3 Outdoor reactors shall be installed in a stacked arrangement, with the centre phase winding direction reversed to reduce mutual coupling between the units. Support structures shall be aluminium or non-magnetic, and inter-phase and ground clearance insulation posts shall have non-magnetic end caps. Magnetic and electrical clearances shall be shown on tender drawings and construction drawings submitted to the Engineer.

4.3.4 The windings of the reactors shall be epoxy impregnated fibre glass encapsulated aluminium conductors with all current carrying connections welded. The insulation shall be suitable for exposure to the climatic conditions and service conditions described in the Project Specification without any premature deterioration.

4.3.5 The reactors shall be of robust construction capable of withstanding the mechanical forces occurring as a result of thermal expansion or contraction, lightning or switching surges.

4.3.6 Support insulators shall have a minimum nominal creepage distance of 25 mm/kV unless otherwise specified in the Project Specification to suit the expected pollution level at the installation site.

5. INDIVIDUAL COMPENSATION FOR MOTORS

5.1 MV Motors

5.1.1 Individual compensation for power factor correction (PFC) shall be provided for MV motors by static capacitors as specified in the Project Specification.

5.1.2 The capacitors shall be installed in adequately-ventilated, free-standing enclosures of painted mild steel with an IP42 rating. Live cable LED indication lights shall be provided on the front of the enclosure. Unless otherwise specified in the Project Specification, the capacitors shall be located in the same room as the motor controlgear.

5.1.3 The capacitors shall be three-phase units which are connected individually or in banks for larger motors.

5.1.4 The capacitors shall be protected by dedicated HRC fuses which shall be equipped with striker pins and connected to automatically trip and lock out the motor starters when the fuses operate. Fuse trip flag relays shall be provided on the motor controlgear panel, with contacts for remote monitoring and alarm.

5.1.5 To ensure that self-excitation of motors does not occur, capacitors shall be rated so that the capacitor current does not exceed 90 % of the motor no load current.

5.1.6 Motor protection relays shall be set to take account of capacitor current.

5.1.7 Individual motor compensation shall not be provided for motors operated together with variable frequency converters (to form variable speed drives).

5.2 LV Motors

5.2.1 Individual compensation for power factor correction (PFC) shall be provided for LV motors by static capacitors as specified in the Project Specification. The capacitors shall be installed inside the associated LV MCCs.

5.2.2 Capacitors for individual motor compensation shall be connected to the outgoing terminals of motor feeders to switch in together with the motors for DOL and reduced voltage starters (other than soft starters).

5.2.3 Capacitors shall be connected to the supply side of soft starters via dedicated contactors which shall only switch in the capacitors when the soft starters' bypass contactors have closed or when the soft starters have reached top of ramp voltage if bypass contactors are not provided.

5.2.4 To ensure that self-excitation of motors does not occur, capacitors which are switched with motors (i.e. which remain connected to motors after they are disconnected) shall be rated so that the capacitor current does not exceed 90 % of the motor no load current.

5.2.5 Motor protection relays and thermal overload relays shall be set to take account of capacitor current.

5.2.6 Individual motor compensation shall not be provided for motors operated together with variable frequency converters (to form variable speed drives).

6. MV GROUP/CENTRALIZED COMPENSATION

6.1 General

6.1.1 Group and centralized compensation for power factor correction (PFC) shall be provided at MV switchboards as specified in the Project Specification.

6.1.2 The compensation shall be provided by automatically switched static capacitors with the number and rating of switched banks (steps) as specified in the Project Specification.

6.1.3 Damping and detuning reactors shall be provided if required to limit inrush currents and to prevent resonance respectively.

6.1.4 When installed indoors the PFC installation shall comprise control panels housing the PFC switchgear and separate free-standing capacitor banks and associated reactors.

6.1.5 When installed outdoors, the PFC switchgear, capacitor banks and associated reactors shall be installed in a proprietary, purpose-built outdoor enclosure.

6.1.6 The PFC installation shall include all equipment required to provide a complete, fully-functional system.

6.2 Switchgear

6.2.1 Switchgear shall be provided as specified in the Project Specification for the switching of the capacitor banks, and it shall comply with Engineering Standard SPE-EP-0002: “Indoor MV (Metal-enclosed) Switchgear.”

6.2.2 Unless otherwise specified in the Project Specification, each switchboard panel associated with a capacitor bank shall contain the following:

a) Switch-disconnector

b) HRC fuses

c) Vacuum or SF_6 contactor

d) Earthing switch

e) Constant voltage transformer (CVT) for control supply

f) Capacitor protection relay

6.2.3 The mechanical and electrical endurance classes of the switchgear shall be as follows:

a) Switch-disconnector: M1 and E2

b) Contactor: C2

c) Earth switch: E2

6.2.4 A key interlock with timed-release shall be provided between the earth switch and the switch-disconnector to ensure that capacitors are sufficiently discharged before the earth switch can be closed.

6.2.5 The control circuits of the PFC equipment and the supply to the PFC controller (if housed in the PFC switchgear panels) shall be provided with power from a suitably rated CVT in order to limit malfunctions due to switching transients and supply system voltage dips.

6.2.6 Each switchboard panel associated with a capacitor bank (step) shall have an LV compartment for housing the following:

a) Capacitor protection relay
b) Control switches and pushbuttons
c) Meters
d) Indication lights

6.2.7 Control switches and pushbuttons shall be provided as follows:

a) An ON/OFF control switch
b) An automatic/manual switch
c) Pushbuttons for controlling the capacitor switching in the manual mode

6.2.8 Indication lights shall be provided for the following:

a) Switch-disconnector open/closed
b) Capacitor bank switched in
c) Alarm condition
d) Protection relay trip
e) Manual mode selected

6.2.9 Meters shall be provided as follows:

a) Three ammeters
b) A PF meter
c) A switching operations non-resettable counter

6.3 Capacitor Protection Relay

6.3.1 Each capacitor step shall be provided with a capacitor protection relay with the following functions:

a) Inverse time/thermal overcurrent (including harmonics)
b) Instantaneous 50 Hz overcurrent
c) Earth fault 50 Hz current
d) Line unbalance 50 Hz current
e) Star point unbalance 50 Hz current
f) Overvoltage 50 Hz
g) Mains supply failure or undercurrent 50 Hz
h) Capacitor bank re-switching inhibit

6.3.2 Unless otherwise specified in the Project Specification, the auxiliary supply voltage shall be 230 V AC. and the voltage and current transformer inputs shall be 110 V AC and 5 A. respectively. The latter shall be provided for line currents and star point unbalance current.

6.3.3 Unless otherwise specified in the Project specification, the relay shall support the Modbus RTU protocol for integration into a PLC/SCADA system.

6.3.4 LED indicators and/or an LCD display shall be provided on the relay face to indicate all trip functions. A minimum of two trip and one alarm output contacts shall be provided.

6.3.5 The Contractor shall provide a complete set of calculations and recommended relay settings to the Engineer one month before commissioning.

6.3.6 Line- and star point (for double star bank) current transformers shall be provided for the protection relay inputs as specified in the Project Specification.

6.4 Power Factor Controllers

6.4.1 Microprocessor-based power factor (PF) controllers shall be provided for the automatic control of the capacitor bank switching as specified in the Project Specification.

6.4.2 PF controllers shall provide the number of switching steps specified in the Project Specification. The following shall be programmable, with all programmed parameters and modes saved in non-volatile memory:

a) Target PF

b) C/k ratio

c) Switching sequence

d) Switching delay times (on, off and reset)

e) Switching strategy

6.4.3 The following measurements and monitoring shall be provided:

a) kW, kVAr and kVA

b) Voltage and current

c) Total harmonic distortion, voltage and current

d) Power factor

e) Voltage and current harmonics (up to 19^{th} minimum)

f) Number of switching per output

g) Temperature of PF controller (and of capacitors if specified in Project Specification)

6.4.4 The PF controllers shall be equipped with an LCD display and keypad for local control, monitoring and programming. If specified in the Project Specification a Modbus (RS485) interface shall be provided for integration of the controller into a PLC/SCADA system.

6.4.5 The PF controllers shall have an output alarm relay and, if specified in the Project Specification, an output fan relay. Alarm logging of at least the last five alarms shall be provided.

6.4.6 PF controllers shall be suitable for the input voltages and currents specified in the Project Specification, and the specified voltage- and current transformers shall be provided.

7. LV GROUP/CENTRALIZED COMPENSATION

7.1 General

7.1.1 Group and centralized compensation for power factor correction (PFC) shall be provided at LV Assemblies as specified in the Project Specification.

7.1.2 The compensation shall be provided by automatically switched static capacitors with the number and rating of switched units/banks (steps) as specified in the Project Specification. A single step shall not exceed 100 kVAr.

7.1.3 Damping and detuning reactors shall be provided if required to limit inrush currents and to prevent resonance respectively.

7.1.4 Unless otherwise specified in the Project Specification, the PFC equipment shall be installed in the LV Assembly at which the global/centralized compensation is provided.

7.1.5 All the PFC equipment, other than the capacitors and reactors, shall comply with Engineering Standard SPE-EE-0010 - "LV Switchgear & Controlgear Assemblies"

7.2 Circuit Breakers and Fuses

7.2.1 A main circuit breaker shall be provided for each complete global/centralized PFC installation to provide short-circuit, overload and earth fault protection. Depending on the amount of compensation provided, this circuit breaker shall be either an MCCB or an ACB as specified in the Project Specification.

7.2.2 Each capacitor step shall be protected by an MCB, MCCB or an HRC fuse, depending on the rating of the capacitor step and fault level.

7.2.3 Circuit breaker and fuse ratings shall be based on the capacitor current and a safety factor of 1,5.

7.3 Contactors

7.3.1 Each capacitor step shall be switched with a contactor rated to carry and switch the capacitor currents (peak inrush and continuous) with a safety factor of 1,5 for the continuous current

7.3.2 Contactors shall have an AC-6b utilization category and shall provide Type 2 coordination with the upstream short-circuit protective device.

7.3.3 Inrush reactors may be omitted if contactors are fitted with damping resistors and are designed for capacitor switching.

7.4 Power Factor Controllers

7.4.1 Microprocessor-based power factor (PF) controllers shall be provided for the automatic control of the capacitor bank switching as specified in the Project Specification.

7.4.2 The PF controllers shall comply with Clauses 6.4.2 to 6.4.6 of this standard specification and shall be set up to provide the following protection:

a) Undervoltage

b) Overvoltage (true RMS)

c) Over-temperature.

8. EARTHING

8.1 General

8.1.1 The PFC equipment shall be earthed in accordance with Engineering Standard SPE-EE-0020 – “MV & LV Earthing” and as specified in the Project Specification.

9. TESTING

9.1 Type- and Routine Tests

9.1.1 Type- and routine tests shall be carried out on capacitors and reactors in accordance with the applicable standards listed in Clause 2.2.

9.1.2 Type- and routine tests shall be carried out on MV switchgear in accordance with the Aurecon Engineering specification listed in Clause 2.2.

9.1.3 Testing of group/centralized LV PFC forming part of LV Assemblies shall be in accordance with the Aurecon Engineering specification listed in Clause 2.2.

9.2 Acceptance Tests

9.2.1 Factory- and/or site acceptance tests shall be carried out where specified in the Project Specification.

9.2.2 Factory- and/or site acceptance tests shall demonstrate the functioning of the complete and integrated PFC installation.

10. DOCUMENTATION AND TRAINING

10.1 General

10.1.1 All PFC equipment 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

10.2 Drawings for Acceptance by the Engineer

10.2.1 All PFC equipment and installation drawings shall be submitted to the Engineer for his acceptance before construction commences.

10.2.2 The drawings shall include full schematics drawings and general arrangement drawings for all PFC equipment.

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

10.3 Testing Documentation and Reports

10.3.1 Test certificates shall be provided for type- and routine testing of all equipment.

10.3.2 Test reports shall be provided for factory- and site tests.

10.3.3 Records shall be provided for all commissioning tests.

10.4 Operating and Maintenance Manual

10.4.1 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.

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

a) All design and manufacturing drawings and documentation relating to the PFC equipment and installation.

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 PFC components.

d) A spares list with parts' and suppliers' details.

e) Operating instructions

f) Maintenance instructions and schedules

g) Protection settings record

10.5 Training

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

a) The Contractor shall conduct training courses on site for the Employer's staff in the maintenance and operation of the PFC equipment. 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 PFC installation 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.

10.5.2 The Employer reserves the right to videotape the training sessions for later use.

10.5.3 Upon completion of the courses the trainees' knowledge shall be formally tested to prove that an acceptable level of competency has been achieved.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Low Voltage Electric Motors

25 June 2015

Revision: 0

Reference: EE-0025

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by **Aurecon**.

Document control						aurecon
Specification title		Low Voltage Electric Motors				
Document ID		EE-0025	**Reference number**		EE-0025	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	M Hendricks	K O'Kennedy	O Fair
Current revision		0				

Approval			
Author signature	M Hendricks	**Approver signature**	
Name	Mike Hendricks	**Name**	O. Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Specification

Fire Detection and Alarm System (FDAS) Installations

18 August 2016

Revision: 0

Reference: EL-0001

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:
a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						aurecon
Specification title		Fire Detection and Alarm System (FDAS) Installations				
Document ID			**Reference number**		EL-0001	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\AURECON STANDARD SPECS\WORKING\E_Building Electronics				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	18 August 2016	Updated to include 1st review comments	K. Adu-Asomaning	K. Adu-Asomaning	C. Reeder	G. Gous
Current revision		**0**				

Approval			
Author signature		Approver signature	
Name	Kwame Adu-Asomaning	Name	G. Gous
Title	Electrical Engineer	Title	Associate (Pr. Eng)

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 The intent of this specification is to ensure the construction of a safe and reliable fire detection and alarm system.

1.1.2 This document specifies the standard requirements for:

a) The supply of fire detection and alarm system equipment.

b) The installation of a fire detection and alarm system.

c) The testing and commissioning of a fire detection and alarm system.

1.2 General

The following definitions are used in this specification:

1.2.1 The term “Employer” shall mean the person named as Employer in the Appendix to the tender and the legal successors in title to this person.

1.2.2 The term “Contractor” shall mean the person(s) named as contractor in the Tender acceptance letter by the Employer.

1.2.3 The term “Engineer” shall mean the person appointed by the Employer to act as the Engineer for the purposes of the contract.

Refer to the Project Specification for the applicable standard to use for the specific project either South African National Standards (SANS) or British Standards (BS).

1.3 System Architecture

1.3.1 The design of the installation shall address the following characteristics:

a) Type of system.

b) Type of protection and coverage.

c) The zoning of the premises.

1.3.2 The system shall consist of a central control unit connected to field devices such as detectors, manual call points and annunciation devices via a cable loop.

1.3.3 The control unit shall continuously monitor the status of all sensing devices and initiate an action according to their status.

1.3.4 The operation of the system shall be configurable according to the Employer requirements.

1.4 System Characteristics

1.4.1 The system shall be an addressable or conventional system capable of communicating with multiple external systems such as fire extinguishing system, smoke detection and extraction system, HVAC system, lifts, access control system, all via logical programmable input/output units.

1.4.2 Field devices shall be connected in a closed loop configuration or individual wires per each device depending on the type of system installed, and connecting back to the main fire panel.

1.4.3 The fire detection control unit shall monitor the status of field devices on a continuous basis.

1.4.4 Based on the information gathered from the field devices, the control unit will report any fault and alarm conditions and initiate the appropriate actions.

1.4.5 The system shall be field configurable from the control panel via a keypad or via a computer workstation. Final configuration should be maintained under power failure conditions.

1.4.6 The system shall have a minimum of four access levels e.g. operator, supervisor, maintenance technician and administrator. The system shall be password protected

1.4.7 The system and all field devices shall be protected against over voltage and transient currents.

1.4.8 The control unit shall be modular in design and have facilities to operate as a stand-alone unit or as part of a network, consisting of multiple control units.

1.4.9 All equipment that requires operation, attendance, cleaning or maintenance in service shall be positioned and installed to allow adequate and safe means of access for such activities. Similarly, the positioning of equipment shall not impede access to any other equipment or services which require operation and maintenance activities.

1.4.10 Where refurbishments in the form of additions or alterations to an existing installation are to be performed, the compatibility of existing and new equipment shall be verified and confirmed in writing to the Engineer before commencement of any works.

1.4.11 Shop drawings and connection diagrams of the Fire Detection System configurations shall be provided by the Contractor.

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 Project Specification, which shall be read in conjunction with this specification.

2.1.2 The supply, construction, 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 or British Standards.

2.1.3 The decreasing order of precedence of these requirements shall be as follows:

a) Statutory requirements.

b) National Standards.

c) Employer's requirements.

d) Particular Specification.

e) Construction Drawings.

f) This Specification.

2.1.4 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 or raised with the engineer in writing by the Contractor.

2.1.5 The Contractor shall operate an auditable quality assurance procedure covering the supply, construction, inspection and testing of the installation.

2.2 Regulations, Specifications and Standards

2.2.1 The supply, 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.

2.2.2 The latest editions (current at the time of Tender) of the following South African National Standards or British Standards shall be included:

Table 1 Standards

SANS Number	BS Number	Description
SANS 10139	BS 5588	Fire detection and alarm systems for buildings – System design, installation and servicing Building Regulations
SANS 10142-1	BS 7671	Wiring of Premises Part 1: Low Voltage Installations
SANS 10400		Building Regulations
SANS 50054-1	BS 5839	Fire detection and alarm systems – Part 1: Introduction
SANS 50054-2	BS 5839	Fire detection and alarm systems – Part 2: Control and indicating equipment
SANS 50054-3	BS 5839	Fire detection and alarm systems – Part 3: Fire alarm devices – Sounders
SANS 50054-4	BS 5839	Fire detection and alarm systems – Part 4: Power supply equipment
SANS 50054-5	BS 5839	Fire detection and alarm systems – Part 5: Heat detectors – Point detectors
SANS 50054-7	BS 5839	Fire detection and alarm systems – Part 7: Smoke detectors – Point detectors using scattered light, transmitted light or ionization
SANS 50054-11	BS 5839	Fire detection and alarm systems – Part 11: Manual call points
SANS 50054-20	BS 5839	Fire detection and alarm systems – Part 20: Aspirating Smoke Detectors

2.2.3 The installation shall also comply with:

a) This specification including any documentation issued by, or on behalf of, the Employer in respect of the installation.

b) EN54 - Fire Detection and Fire Alarm Systems.

c) British Standards BS 5839 Pt1 - Fire Detection and Fire Alarm Systems for buildings. Code of practice for design, installation, commissioning and maintenance of systems in non-domestic premises.

d) National Fire Protection Association, NFPA Part 13 – Installation of Sprinkler Systems.

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.

c) Mechanical properties.

3.2 Fire Detection Control Panel

3.2.1 General

a) The control panel shall have a front panel comprising of a LCD screen, control keyboard and indicating LED's.

b) The control panel shall be a 24Vdc analogue addressable or conventional unit and be able to communicate with various field devices.

c) The control panel will not only read the address of each individual unit, but also receive their true analogue value.

d) The control panel will be equipped with a minimum of 2 loops and a minimum 64 zone capacity and be upgradeable to the maximum prescribed loops as per the project specification without the need for additional housing.

e) Each loop shall consist of a 2 wire cable. These 2 wires will power the field devices and carry data to and from these field devices. Each loop will allow for a minimum of 127 addresses. The specific number of addresses required shall be specified in the project specification.

f) The fire panel will not have any pre-set configuration of field device addresses. Address configuration will be determined during commissioning.

g) The fire panel shall be able to determine the type of device located at each address to protect against incorrect programming.

3.2.2 Annunciation

a) LED indicators shall show faults and fire alarms by zones.

b) The following conditions will be clearly displayed on the LCD text display along with an audible alarm and where applicable the LED indicators:

i) Fire alarms by zone.

ii) Pre-alarms.

iii) System faults.

iv) Maintenance indication level.

v) Device or zone that has been disabled.

vi) Total number alarm events.

3.2.3 Fire alarms shall take priority on the LCD display.

3.2.4 On manual request it shall be possible to view field devices, along with their analogue addresses and current status.

3.2.5 Different types of alarm conditions must be clearly distinguishable.

3.2.6 The control panel shall provide communication outputs for network capabilities, audible alarms, control functions, remote mimics, a printer and a computer workstation.

3.2.7 The control panel shall be able to receive and transmit various inputs and outputs to and from e.g. sprinkler systems, air conditioning installations, lifts etc.

3.3 Power Supply

3.3.1 Power Supply

a) A control panel shall be fed from a 230V supply or an emergency (standby) mains power supply.

b) Power supply to be fed from the nearest distribution board via a dedicated switched socket outlet or isolator.

c) Conductor size shall be a minimum of 2.5 mm² PVC insulated.

d) The standby batteries for the system shall be capable of providing a minimum standby time of 24 hours with the system in alarm state.

3.4 Detectors

3.4.1 General

a) All detectors shall be of the analogue addressable or conventional type as indicated in project specification. Each detector shall be assigned with a unique address. It shall be possible to set individual addresses in the field.

b) Detectors shall be suitable for connecting to a two-wire 24Vdc circuit and operate within the supply voltage range of 17 - 28Vdc. The detectors shall also be polarity insensitive.

c) A red indicator LED shall be provided on each of the detectors, the LED will illuminate when a pre-set alarm level has been reached.

d) Provision shall be made for a remote indicator output on each detector.

e) All detectors are to be supplied complete, fully tested and calibrated.

f) Detectors shall be capable of being remotely tested from the fire panel via transmission of a test code. A healthy response will indicate that that detector has exceeded its alarm threshold and is now in alarm mode.

g) The detector shall be capable of operating within the following environmental range:

i) Temperature range: -20°C to 60°C.

ii) Humidity range: 0% to 95%.

iii) Ingress Protection rating: IP 43.

3.4.2 Detector Base

a) Separate mounting bases are required to enable easy removal of detectors for maintenance and replacement purposes.

b) There shall be a facility on each base for inserting an indicator tag. The indicator tag shall be clearly visible and indicate the base address.

c) Bases shall be fitted with stainless steel terminal spring, terminal screws and saddles.

d) Insertion and removal of field devices shall be through a twist operation of the device.

3.4.3 Photoelectric or Optical Smoke Detector.

a) The optical smoke detectors shall be suitable for detecting visible smoke such as produced by smouldering fires including burning PVC.

b) It shall be of the light scattering type using a pulsed internal LED light source and a photocell sensor.

c) The construction of the detector shall be of self-extinguishing ABS plastic. Circuitry shall be protected against moisture. Smoke entry points must be protected against dust and insects. The detector covers shall remain on during construction to prevent dust contamination and shall only be removed prior to testing and commissioning.

d) Detectors maximum mounting ceiling height shall be 12.5 m.

e) The contamination level of a detector's photo-optical chamber will cause the detector output signal to gradually change. The control panel shall be capable of monitoring this change in signal and indicate when a level is reached that requires servicing of the detector.

3.4.4 Thermal Heat Detector:

a) The Detector shall monitor ambient temperature by means of an exposed transistor.

b) The construction of the detector shall be of self-extinguishing ABS plastic. Circuitry shall be protected against moisture.

c) Detectors maximum mounting ceiling height shall be 7.5 m.

d) All heat detectors shall have both rates of temperature rise and maximum temperature level detection capabilities.

3.4.5 Infra-red Flame Detector

a) The flame detector must be of the dual infra-red type and include solar blinding.

b) Both alarm and fault relays must be incorporated.

c) The detector spectral response distance shall be between 1 and 2.8µm.

d) The detector shall be capable of detecting hydrogen flames.

3.4.6 UV Flame Detector

a) Both alarm and fault relays must be incorporated.

b) The ultra violet flame detector shall have a spectral response distance of between 185 and 260 nm.

c) The detector shall have a field of view of no less than 100°.

3.4.7 Multi Detector

a) A multi detector shall have both thermal and optical sensing capabilities; these are to provide warning on both types of alarm conditions.

b) Multi detectors shall fully comply with the requirement as specified for optical and thermal detectors.

c) The optical and thermal element of a multi detector shall be able to report to the fire panel individually

3.4.8 Linear Beam Detectors

a) Linear beam detectors shall comply with EN45-12 and shall measure smoke obscuration of an infrared beam between two points from 8m to 100m apart.

b) They shall be reflective type requiring active electronics at only one end of the beam with a passive reflector at the other end.

c) It shall be possible to power the beam detector directly from the address loop.

3.4.9 Aspirated High Sensitive Smoke Detectors

a) Aspirated High Sensitive Smoke Detectors (HSSD) shall comply with SANS 50054-20/EN54-20.

b) The HSSD shall be of an aspirated type and shall be able to draw a sample of the atmosphere in a protected space via fans or pipework into the fire detector usually installed remotely from the protected space

c) It draws air from aspirated pipe lengths to a laser based smoke detector capable of sensing smoke down to obscuration levels.

d) The fire alarm threshold and the two pre-alarm threshold shall be configurable

e) All HSSD detectors shall have the facility to adapt their sensitivity automatically to ambient conditions.

f) The specification of the pipes shall be as indicated in the project specification.

3.5 Manual Call Points

3.5.1 Break Glass Unit

a) The construction of the unit shall be of red self-extinguishing polycarbonate plastic.

b) The unit shall be operated by breaking the glass insert, and the alarm condition shall be maintained until the glass insert has been replaced.

c) A red indicator LED shall be provided on each of the units; the LED will illuminate when the glass insert is broken and indicate the alarm status.

d) The glass insert shall be replaceable using a re-settable tool.

e) It shall be possible to test each unit by inserting a test tool at the bottom of the unit. This test tool shall simulate an alarm condition, without breaking the glass

f) The unit shall be fitted with a cover and seal to eliminate tampering.

g) The unit shall be mounted on a 100mm x 100mm back plate and not directly against walls and concrete surfaces.

3.6 Isolators

3.6.1 Zone or Loop Isolator

a) The isolator shall be able to connect into the loop circuit and monitor the loop for short circuits.

b) In the event of a short circuit, the isolator on each side of the short circuit is to disconnect and isolate the short circuit. This will enable the remainder of the system to function normally.

c) A red indicator LED shall be provided on each of the units, the LED will illuminate when the isolator is in the open position.

3.7 Input/Output Units

3.7.1 General

a) The I/O units shall be connected to and powered from the same two wire loop as the detectors and manual call points for the designated area.

b) The unit shall allow for “Normally Open” and “Normally Closed Contacts”

c) All inputs shall be monitored by an end of line resistor.

d) All outputs shall be changeover relays. The relays shall be of the magnetic latch type to limit current consumption on the two wire loop.

e) A red indicator LED shall be provided on each unit, the LED will illuminate when any fault condition occurs at the I/O unit.

f) Each I/O unit shall only be assigned one unique address, but nevertheless allow for individual operation of that module's inputs or outputs.

3.7.2 The minimum available range of units shall be as follows:

a) 1 Input module

b) 2 Input / 1 Output module

c) 2 Input / 2 Output module

d) 4 Input module

e) 4 Input / 4 Output module

3.8 Annunciation Devices

3.8.1 Siren/Strobe Circuit Controller

a) The controller shall be connected to the two wire loop and locally drive and monitor sirens external to the closed loop.

b) The controller shall have its own power supply and operate through polarity reversal.

c) The controller shall monitor the following:

i) Siren loop for short and open circuit.

ii) Its own 24Vdc power supply with standby time of 24 hours in alarm mode.

iii) The mains voltage before rectifying.

d) A Controller should be able to operate continuously for a fire alarm within its zone and any adjacent zones. This operation should be programmable.

3.8.2 Loop Siren

a) Sirens shall comply with the following minimum specifications:

i) Operating voltage	:	24 Vdc
ii) Current consumption	:	18 mA
iii) Sound output	:	101dB at 1 m
iv) Indoor ingress protection	:	IP 41
v) Outdoor ingress protection	:	IP 65
vi) Operation temperature	:	-10°C to +60°C

b) The Siren shall be constructed from a red self-extinguishing ABS plastic and be supplied along with a siren base.

3.8.3 Strobe Light

a) Strobe lights shall comply with the following minimum specifications:

i) Operating voltage	:	24 Vdc

ii) Current Consumption : 68 mA

iii) Flash energy : 0.7 Joule

iv) Flash frequency : 1 Hz

v) Indoor ingress protection : IP 41

vi) Outdoor ingress protection : IP 65

vii) Operation temperature : -10°C to +60°C

b) The strobe light body shall be constructed from a red self-extinguishing ABS plastic. The lens will be constructed from a polycarbonate plastic.

3.8.4 Strobe/Siren combination

a) A strobe/siren combination unit shall fully comply with the requirement as specified for sirens and strobe lights.

b) The siren and strobe light elements of the combination unit shall be able to receive communications from the fire panel individually.

3.9 Remote Link

3.9.1 Remote link to the fire brigade

a) Transmitting equipment shall be required to submit a general fire alarm to the local fire brigade.

b) The transmitting equipment shall be fully compatible with the receiving equipment already installed at the fire brigade. The type of transmitting equipment is therefore dependant on the type of equipment the fire brigade has installed. It is the Contractors responsibility to ensure compliance.

c) The output to the fire brigade shall be a monitored output.

3.10 Software Package

3.10.1 Monitoring and configuration software package

a) A software package shall be provided along with the fire detection control panel, which shall provide for the following minimum functions:

i) System configuration

ii) Event logging

iii) Alarm acknowledgement

iv) Password protection

b) The software package installed shall come complete with license and installation disks.

c) Renewal of licence shall be included. No yearly subscription shall be allowed

3.11 Cabling

3.11.1 Fire Detection Loop cable

a) The 2 wire cable shall be of the PH 30 as minimum requirement fire retardant type with red outer sleeve. This cable shall have 30 min survival time according to SANS 50200 or BS84-34 part 2.

b) Enhanced fire resisting cables shall have PH 120 classification and should have 120 min survival time according to SANS 50200 or BS84-34 part 2.

4. INSTALLATION OF COMPONENTS AND EQUIPMENT

4.1 General

4.1.1 All equipment shall be securely mounted using proprietary fixtures and fittings.

4.1.2 The method of equipment installation shall not adversely affect the function or structural integrity of the structure to which the equipment is attached.

4.1.3 The method of equipment installation shall not compromise the IP rating of the equipment.

4.1.4 Framework and brackets

a) Unless otherwise approved in the Project Specification, site-fabricated framework and brackets shall not be used.

b) Framework and brackets shall be positioned so as not compromise 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.

d) Fasteners securing equipment to framework and brackets shall be independent of those securing framework and brackets to walls and floors.

4.1.5 Positioning of Equipment

a) Final positions of equipment shall be agreed on site, prior to installation.

b) Equipment shall be positioned with due regard to the aesthetics of the installation.

4.1.6 Unless otherwise specified, mounting heights shall be as follows:

Table 2 Mounting Heights

	top frame 2000 mm above finished floor level
I/O Units	underside 2200 mm above finished floor level
Manual Call Points	underside 1200 mm above finished floor level

4.1.7 The detectors and detector bases shall always be installed in such a way that the indicator tag and LED alarm indicator is easily seen from the point of access to that area.

4.1.8 All surface mounted equipment shall be solidly fixed to walls or soffits by means of their back plates.

4.2 Cables

4.2.1 The cable installation shall comply with the requirements of SANS 10142-1 or BS 7671

4.2.2 Cables shall, as far as possible, run parallel with the lines of building construction.

4.2.3 Cables and their support systems shall not be fixed to protective barriers, guards or direct to guard-rails.

4.2.4 Cables shall be installed strictly according to the manufacturers' requirements pertaining to:

a) Maximum tensile or compressive stresses (e.g. due to pinching or squashing).

b) Minimum bending radius.

c) Temperature of installation.

d) Operating environment.

4.2.5 Installation of Cables in Conduit

a) The cable installation in the conduit shall conform to part 6.5.6 of SANS 10142-1 or BS 7671.

b) Conduit shall be debugged and swabbed prior to cables being pulled in.

c) The entire conduit system shall be complete prior to installing cables.

d) Loops supplied from different fire control panels shall not be installed in the same conduit.

4.2.6 Looping and joints

a) A loop-in wiring system where conductors are looped from outlet to outlet shall be employed.

b) No joints shall be allowed in the cables without the prior approval of the Engineer.

c) The use of PVC insulation tape is not acceptable.

4.2.7 Pulling-through of conductors

a) 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.

b) 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.

4.2.8 Cabling inside vertical wire ways

a) Conductors installed in vertical wire ways shall be secured at intervals not exceeding 2000mm to support the weight of the conductors.

b) Proprietary or approved clamps shall be supplied and installed in suitable draw-boxes for this purpose.

4.2.9 Method of Cable Support

a) Fixing of cables to containment shall be via appropriate cable metallic straps, clamps and clips.

b) No cable ties shall be used in the installation.

c) Cables should be strapped to cable containment or supports every 500mm.

d) The methods of cable support should be non-combustible and their installation should not in any way compromise the integrity of the circuit. The cable support material should be of a material that can withstand a similar temperature and duration to that of the fire rated cable whiles maintaining adequate support.

5. DRAWINGS AND DOCUMENTATION

5.1 Generals

5.1.1 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.

5.1.2 All documentation shall be detailed and be written to enable any supplier or maintenance organization to maintain the system.

5.2 Drawings

5.2.1 "As-built" drawings shall be computer generated through a recognised CAD software package. Drawings submitted for acceptance shall be provided on A3 paper size.

5.2.2 Final "As-built" drawings shall be submitted in A0 paper format and in PDF format, on CD. Paper copies are to be neatly folded and placed in a perspex cover sleeve.

5.2.3 The detailed "As-built" drawings shall be provided by the Contractor showing positions of the following.

a) Equipment (e.g. Panels, Detectors, Sirens etc.).

b) Wire ways (e.g. Conduit, Cables ladder, Cable Trays etc.).

c) Cable Routes.

5.3 Mimic Panels

5.3.1 Passive Mimic Panels

a) The panel shall consist of a laminated paper display placed inside an aluminium frame behind a clear perspex sheet. The size will be project dependant.

b) The following shall be clearly indicated on the display:

i) Building floor plan.

ii) All field devices.

iii) Zones clearly outlined in colour.

iv) Building name.

v) "You are here" arrow.

c) The laminated paper display placed inside an aluminium frame shall be computer generated through a recognised CAD software package.

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, all in A4 format. One electronic set shall also be provided in CD or DVD format. The operating and maintenance manuals shall include at least the following:

a) A schedule of all components in the installations with the following information provided:
   i) Manufacturers name and contact details
   ii) Loop and Zone
   iii) Function
b) Full description and details of design capacity and design criteria for each item of equipment and each product.
c) Detailed description of the function of all operator controls.
d) Procedures for fault finding.
e) Maintenance instructions for all components, including repair, overhaul, change-out and installation procedures.
f) Inspection schedules.
g) Testing procedures.
h) Commissioning procedures.
i) Operator training manuals.
j) “As-built” drawings.

6. TESTING AND COMMISSIONING

6.1 General

6.1.1 The installation shall be inspected and tested in accordance with all the SANS 10139.

6.1.2 Inspection and testing shall only be performed by personnel with approved and 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 be covered by a current test and calibration certificate.

6.1.4 Unless otherwise specified in the Project Specification, all inspection and test results shall be recorded using proforma documentation (test certificates and schedules) complying with SANS 10139 or BS 5839 or BS 5588.

6.1.5 The SAQCC certificates to be issued once final commissioning has been completed. Contractor to submit report to Engineer.

6.1.6 The Contractor shall make provision for all inspection and testing activities to be witnessed by the Engineer. Unless otherwise specified in the Project Specification, the period of notice for witness testing shall be 5 working days.

6.1.7 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 Project Specification.

6.1.8 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 Testing and Commissioning

6.2.1 Before testing and commissioning, inspections shall be performed to verify:

a) All equipment and material is of the correct type and complies with applicable SANS or BS standards.

b) All parts of the installation are correctly installed.

c) No part of the installation is visibly damaged or otherwise defective.

d) The installation is suitable for the environmental conditions.

e) The installation complies with this Specification.

6.2.2 On satisfactory completion of the inspections the following tests shall be performed in the sequence listed:

a) A power failure shall be simulated to test the standby power supply.

b) Cables and wiring should be insulation tested at 500V after they are installed. The insulation resistance to earth and between conductors should comply with the requirements of SANS 10142-1 or BS 7671. Because 500V can damage electrical and electronic equipment, the insulation test should be carried out before equipment is connected to the cables or wire. The completed installation should be tested at a lower voltage, as recommended by the manufacturer.

c) Earth continuity should be tested in accordance to SANS 10142-1 or BS 7671.

d) Each detector and manual call point should be dynamically tested to ensure that they work satisfactorily, and that the correct indications and responses are given by the fire control panel.

e) The siren should be tested to ensure that the correct sound levels are achieved throughout the building.

f) All signals from the fire control panel to ancillary systems should be checked to ensure that the correct actions or responses are achieved.

g) The remote link to the fire brigade should be tested if installed.

h) After individually testing the components and equipment, fire simulation tests shall be done to commission the system and to indicate that the system is working.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Engineering Standard

Battery Tripping Units

25 June 2015

Revision: 0

Reference: EP-0004

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title		Battery Tripping Units				
Document ID		EP-0004	**Reference number**		EP-0004	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	ACJ Lombard	JJ Hattingh	AJ Zwiegers
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Adriaan Lombard	**Name**	Andries Zwiegers
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the design, manufacture, testing, delivery to site, site erection, site testing, commissioning and handover of a Battery Tripping Unit (BTU) for indoor application of for MV switchgear.

1.2 General

1.2.1 The following definitions are used in this Specification:

a) The term “Employer” shall mean the person named as Employer in the Appendix to tender and the legal successors in title to this person.

b) The term “Contractor” shall mean the person(s) named as Contractor in the letter of Tender accepted by the Employer.

c) The term “Engineer” shall mean the person appointed by the Employer as the Engineer for the purposes of the contract.

1.3 Electrical System Characteristics

1.3.1 The operating conditions of the electrical system as stipulated elsewhere in the tender documentation shall be complied with.

1.4 Installation Performance Requirements

1.4.1 The BTU installation shall be suitable for its intended duty with respect to the electrical supply, distribution, and load requirements.

1.4.2 The BTU installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.

1.4.3 The BTU installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components.

1.4.4 The BTU installation shall be compatible with existing equipment, plant, machinery and services.

1.4.5 The installation, including its circuit arrangements, shall satisfy the operational and functional requirements of the Employer and be readily and easily maintained throughout its operating life.

1.4.6 Unless otherwise specified in the Particular Specification, the minimum operating life of the installation shall be 30 years.

2. STANDARDS

2.1 Regulations, Specifications and Standards

2.1.1 The BTU switchgear and the installation thereof shall be in accordance with the latest editions (current at the time of Tender) of all relevant National and International Standards, including but not limited to:

Table 1: Reference Standards

Standard Number	Description
SANS 1091	National colour standard
SANS1652	Battery Chargers
SANS 10142-1	The wiring of premises Part 1: Low-voltage installations
SANS1632 & BS6290	Batteries
SANS ISO 9001 & 14001	Quality Management
SANS IEC 60439	Low-voltage switchgear and control gear
SANS IEC 60529	Degree of protection (IP rating)

2.1.2 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 SPECIFICATION

3.1 Service Conditions

3.1.1 The climatic conditions of the site under which the BTU will operate are specified in the Particular Specification. Furthermore, the electrical parameters of the electrical system containing the switchgear for which the BTU will be used are also specified in the Particular Specification. The BTU shall be suitable for all applicable specified conditions.

3.2 Extent of Works

3.2.1 The Contractor will be responsible for the delivery, off-loading and erection on site, testing and putting into operation of the BTU.

3.2.2 The Contractor shall furthermore be responsible for checking all connections made by others and for commissioning the BTU.

3.2.3 Any damages to the equipment during transport and/or erection and/or connecting up, etc. shall be made good to the satisfaction of the Engineer.

3.3 Distribution Board Construction

3.3.1 General

The distribution board shall be of the totally enclosed, floor mounted type and shall be vermin proof and where possible dustproof. Unless specified otherwise elsewhere, the distribution board shall have a minimum enclosure rating of IP 45 to SANS 60529 or Equivalent International Standard. All components including screws, nuts, bolts, washers, etc., used in the construction of or fixing of components shall be rendered corrosion proof.

3.3.2 Doors

a) Doors shall be suitably braced and stiffened to carry the weight of equipment installed in doors and to prevent deforming.

b) Panel doors shall be fitted with handle closing mechanisms. Alternatively, captive knurled bolts designed to be screwed in by hand may be used.

c) Doors shall have stops to prevent over swing of the door when opening.

d) Doors shall be fitted with suitable rubber or synthetic rubber seals.

e) All doors shall be bonded to the framework by a braided copper earth strap.

3.3.3 Earthing

a) All metal parts other than those forming part of electrical circuits shall be connected to the cubicle earth bar.

b) All non-current carrying conductive parts, including relays, instruments, etc. shall be effectively connected to the earth bar either by means of their mounting arrangements on the board or by means of a special earthing conductor fitted with lugs for attaching to the earth bar.

3.4 Finish

The distribution board of the BTU shall be finished with a high quality paint applied according to the best available method. The final colour is specified in the Detailed Technical Specifications.

4. TECHNICAL SPECIFICATION

4.1 General

4.1.1 Detailed technical requirements for the BTU are specified in the Technical Datasheets.

4.2 Battery Tripping Unit

4.2.1 A battery tripping unit, suitable for connection to a 230 V, 50 Hz, single-phase a.c. supply shall be provided with each switchboard.

4.2.2 The charger shall be metal-enclosed and shall be suitable for charging Ni-Cad batteries with voltage and capacity as specified in the Detail Technical Specification. The charger shall be such that the change-over from trickle to boost charge is automatic.

4.2.3 The tripping unit shall be supplied complete with fuses on the a.c. supply side and on the outgoing d.c side of the charger, an ammeter to indicate the charging rate, a voltmeter with spring-loaded push buttons to indicate battery voltage and a circuit to test the state of battery charge.

4.2.4 The capacity of the battery tripping unit shall comply with the requirements of the switchgear manufacturer, or alternatively with the minimum requirements that are stipulated in the Particular Specification.

4.2.5 The battery tripping units shall be of the indoor type. They shall be floor standing and fitted over the cable trenches. The enclosure of the battery tripping unit shall be manufactured from 1.6 mm sheet steel. All hinges shall be of the stainless steel type and three point locking mechanisms shall be fitted to the doors.

4.2.6 The complete enclosure shall be painted and the final colour shall be confirmed upon the approval of manufacturing drawings.

4.2.7 The battery tripping unit shall be fitted with a complete battery management system that includes full alarms, earth fault alarms and automatic eight (8) hour battery circuit tests.

4.2.8 The battery bank of the battery tripping unit shall be complete with intercell connectors. Complete operation and maintenance manuals, including a wiring diagram shall be provided.

5. TESTING AND COMMISSIONING

5.1 General

5.1.1 The BTU and the batteries shall be tested by the manufacturer. Test certificates, detailing the results of all tests, shall be submitted to the Engineer, together with all the operating and maintenance manuals of the equipment. All defects detected as a result of testing shall be rectified by the Contractor and shall be the Contractor's expense.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Medium Voltage Electric Motors

25 June 2015

Revision: 0

Reference: EP-0008

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title	Medium Voltage Electric Motors					
Document ID	EP-0008		**Reference number**	EP-0008		
File path	N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First Issue	M Kriel	JNF O'Kennedy	M Hendricks	AJ Zwiegers
Current revision	**0**					

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Andries Zwiegers
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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, medium voltage (also commonly designated “high voltage”), 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, unless the size requires that the motor be a specially engineered motor.

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 medium voltage, three phase, resistively 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 variations, as defined in SANS 60034-1 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 A and B.

3.3.3 Unless otherwise stated in the Project Specification, the supply harmonic voltage factor and the supply voltage negative-sequence component shall be as stated in SANS 60034-1.

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 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 nominal 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 Motors 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 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 Frame surface cooled motors shall have cast iron frames, feet and bearing housings, and cast iron or steel terminal boxes.

3.7.2 Motors fitted with integral heat exchangers (air-to-air or air-to-water) shall be manufactured out of cast iron or welded steel.

3.7.3 For submersible motors 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 for the earthing of motor cable screens.

3.10.2 An additional earthing terminal shall be fitted on the motor frame external to the terminal box for the connection of the motor supply earth continuity conductor.

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 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 to suit the specified operating environment and provide an acceptable motor 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 All motors 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.

4.5.2 The wires of all detectors shall be wired to a terminal strip in a dedicated terminal box on the motor.

4.5.3 For submersible pumps the pump bearings shall also be fitted with RTDs of the PT100 type.

4.6 Cooling

4.6.1 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.

4.6.2 Where motors are required to be fitted with integral heat exchangers, these shall be air-to-air (IC 611) or air-to-water (IC81W) as specified in the Project Specification.

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 of duty points, 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 The minimum uncorrected full load power factor shall be 0,85 and the minimum full load efficiency shall be 0,95.

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 cage induction motors shall be suitable for direct-on-line starting at full voltage, regardless of the starting method employed.

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 Unless otherwise specified in the Project Specification, the 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.

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 appropriate to the motor rated voltage.

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 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 The terminal box shall be fitted with a detachable metal gland plate or cable box to suit mechanical compression cable glands for terminating 3-core XLPE/SWA/PVC cables. Where single core XLPE/AWA/PVC 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 Regreasable bearings shall be conservatively loaded to provide a greasing interval of at least 4000 hours. Grease nipples, fitted with extension tubes where access is restricted, shall be provided to allow regreasing while the motor is in operation.

7.1.6 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.

7.1.7 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.

7.1.8 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.

7.1.9 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'. The heater supply shall be protected by a residual current device (earth leakage unit) rated at 30 mA.

9. HAZARDOUS AREAS

9.1 Hazardous Area Application

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

9.1.2 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.

9.1.3 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 (e.g. cooling method IC416). A separately-powered fan shall similarly be provided for the primary coolant if required (e.g. 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) and a DE shorting earth strap, as considered appropriate by the motor manufacturer.

10.1.8 Testing

If specified in the Project Specification, running speed vs. torque curves, drawn over the complete operating range, shall be provided and noise level measurements shall be taken (if requested by the Engineer) during commissioning in accordance with Clause 5.4 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:

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) The Manual's format shall be of A4.

c) Full description and details of design capacity and design criteria for each item of equipment and each product.

d) Procedures for fault finding.

e) Maintenance instructions for all motors and components and including repair, overhaul, change-out and installation procedures.

f) Details of the maintenance tasks and schedules required to achieve the specified motor asset life.

g) 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 heavily 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 1804-1 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 1804-1 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

a) Before testing, inspections shall be performed to verify:

i) All motor earth connections (frame and terminal box) are in place and tightened

i) Motor coupling guards are in place and securely fixed

ii) Power cables are correctly connected and tightened to correct torque

iii) The motor and its immediate environment are clean Tests before motor starter is energized

12.2.2 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

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Distribution Transformers

25 June 2015

Revision: 0

Reference: EP-0023

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control							aurecon
Specification title		Distribution Transformers					
Document ID		EP-0023	**Reference number**		EP-0023		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**	
0	25 June 2015	First Issue	M Kriel	ACJ Lombard	JJ Hattingh	AJ Zwiegers	
Current revision		**0**					

Approval			
Author signature		**Approver signature**	
Name	Adriaan Lombard	**Name**	Andries Zwiegers
Title	Electrical Engineer	**Title**	Electrical Engineer

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This document specifies the standard requirements for the design, manufacturing, testing, delivery to site, site erection, site testing, commissioning and handover of Distribution Transformers that is small transformers below 3150 kVA.

1.2 General

The following definitions are used in this Specification:

1.2.1 The term “Employer” shall mean the person named as employer in the Appendix to tender and the legal successors in title to this person.

1.2.2 The term “Contractor” shall mean the person(s) named as contractor in the letter of Tender accepted by the employer.

1.2.3 The term “Engineer” shall mean the person appointed by the Employer as the Engineer for the purposes of the contract.

1.3 Electrical System Characteristics

1.3.1 The operating conditions of the electrical system to which the Distribution Transformer shall connect, is stipulated in the Particular Specification.

1.4 Installation Performance Requirements

1.4.1 The distribution transformer installation shall be suitable for its intended duty with respect to the electrical supply, distribution, and load requirements.

1.4.2 The distribution transformer installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.

1.4.3 The distribution transformer installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components parts.

1.4.4 The distribution transformer installation shall be compatible with existing equipment, plant, machinery and services.

1.4.5 The installation, including its circuit arrangements, shall satisfy the operational and functional requirements of the Employer and be readily and easily maintained throughout its operating life.

1.4.6 Unless otherwise specified in the Particular Specification, the minimum operating life of the installation shall be 30 years.

2. STANDARDS

2.1 Regulations, Specifications and Standards

2.1.1 The distribution transformer and the installation thereof shall comply with the latest editions (current at the time of Tender) of all relevant National and International Standards, including but not limited to:

Table 1: Standards

Standard Number	Description
SANS 555	Unused and reclaimed mineral insulating oils for transformers and switchgear
SANS 780	Distribution Transformers
SANS 1037	Standard Transformer Bushings
SANS 1091	National Colour Standards
SANS 10064	Preparation of Steel Surfaces for Coating
SANS 10111	Engineering Drawings
SANS 60044	Current Transformers
SANS-IEC-606:1978	Application guide to power transformers
SANS-IEC 60076-1	Power transformers Part 1: General
SANS-IEC 60076-2	Power transformers Part 2: Temperature rise
SANS-IEC 60076-3	Power transformers Part 3: Insulation levels, dielectric tests and external clearances in air
SANS-IEC 60076-4	Power transformers Part 4: Guide to the lightning impulse and switching impulse testing - Power transformers and reactors
SANS-IEC 60076-5	Power transformers Part 5: Ability to withstand short circuit
SANS-IEC 60076-7	Power transformers Part 7: Loading guide for oil-immersed power transformers
SANS-IEC-60076-10	Power transformers Part 10: Determination of sound levels
SANS-IEC-60137	Insulated Bushings
SANS ISO 9001 & 14001	Quality Management
SANS 1274:2005	Coatings applied by Powder Process
BS2562	Specification for cable boxes for transformers and reactors
SPE-EE-0002	Aurecon Engineering Standard for Training, Testing and Commissioning

3. TECHNICAL SPECIFICATION

3.1 Design Criteria and Material of Construction

The detailed technical requirements of the transformer are stipulated in the Technical Datasheet.

3.1.1 General

Except where more rigorous values are stated elsewhere in the tender document, the maximum allowable values for voltage and current harmonics as specified by NRS 048 shall be assumed as standard operating conditions, with the transformer design incorporating mitigation measures to reduce thermal effects as well as power quality both up and downstream of the transformer.

3.1.2 Core and Windings

a) The winding shall be either copper or aluminium and shall be in accordance with SANS 780. The insulation shall be uniform (fully insulated) irrespective of the earthing topology, that is no insulation grading allowed.

b) The coil clamping shall be arranged to compensate for any shrinkage of insulation which may occur. The coil shall be treated to prevent corrosion and the Contractor shall provide details of how coils can be replaced if necessary.

3.1.3 Fault Withstand Capability

a) The transformer(s) shall withstand, without any injurious effect, all stresses produced when a through fault of the level mentioned in the Technical Datasheet is maintained for one second and under all fault conditions/tests specified in IEC 60076.

b) The fault level shall NOT be reduced by series connected devices.

3.1.4 Transformer Losses

a) As low-loss transformers are required, should, in the Engineer's opinion, either the no-load losses or the full-load losses of the transformers supplied by the Contractor exceed the loss figures provided by him in his tender by a quantity exceeding the permissible tolerances in accordance with paragraph 9 of SANS 780, the Engineer shall retain the right to either (a) not accept the transformers, or,(b) to call for changes to be made to the transformers before acceptance. Any such changes shall be approved by the Engineer and shall be at the cost of the Contractor.

b) Where any transformer is accepted for which the no-load or full-load losses exceed the tender figure by a quantity exceeding the permissible tolerances in accordance with paragraph 9 of SANS 780, the tender price shall be adjusted and reduced by a sum equal to the capitalized value of the excess losses, calculated in accordance with the following capitalization formula:

   $K = 1{,}46V + 2{,}86N$

   Where

   K = capitalized value of the losses in South African Rand (ZAR), or the currency applicable to the contract

   V = full-load losses at normal voltage and frequency, in watts

   N = no-load losses at normal voltage and frequency, in watts.

c) In view of adjusting the tender price, the said excess losses shall be taken as the quantity by which the actual loss figure exceeds the loss figure given in the tender, without taking into consideration the permissible tolerances in accordance with paragraph 9 of SANS 780.

d) The no-load and full-load losses will be taken into consideration independently when calculating the adjustment of the tender price. Low full-load losses will therefore not be able to compensate for high no-load losses, or vice versa. Neither shall the tender price be increased should the actual no-load losses and/or full-load losses be less than the losses tendered.

e) The above capitalization formula with V and N as tendered loss figures shall be used in adjudicating the tender.

3.2 Manufacturing and Construction Details

3.2.1 General

Unless specified otherwise elsewhere, transformers with a rating of up to 315 kVA shall be hermetically sealed. Transformers having a larger capacity shall be of the free-breathing type in accordance with SANS 780.

3.2.2 Interchangeability

All transformers of any one type shall be identical and interchangeable with one another at short notice. No alteration to control circuits shall be permissible for this purpose except by means of built-in terminal boards fitted with links for effecting the alteration. All parts are to be made accurately to dimensions so that any corresponding part will be interchangeable and any spare part will fit into place without need of adjustments. Where similar equipment has previously been supplied, components shall interchange with those on previous contracts, unless otherwise approved.

3.2.3 Connections and Wiring

a) All connections shall be securely fastened to ensure good electrical conductivity without abnormal localised temperature rise.

b) All power connections to be made to the transformer shall be onto copper, or tinned copper flags or studs.

c) Care shall be taken to thoroughly check all power connections ensuring that terminations are secure, correctly designed and free from possible oxidation or corrosion.

d) All connections and wiring (Power and Control) shall be copper and suitably rated. All terminations shall use an appropriate brazed or crimped accessory for termination. Pressed tube type accessories are preferred. Hydraulic crimping shall be used for all round conductors of cross sectional area in excess of 16 mm^2. The use of stamped, folded, split-barrel type lugs is prohibited.

e) All insulation used on electrical conductors/connectors, wiring and cabling shall be flame retardant type and shall be from low toxicity, non-halogenated materials.

f) The minimum cross sectional area of small wiring (control, relay, etc.) shall be not less than 2,5 mm^2, 7-strand. Wiring shall be marked by means of numbered ferrules, durable adhesive numbering tapes or other approved means.

g) Internal LV connections shall be suitably-rated flexible copper strips; NOT multi-wired insulated cable.

h) Connections between the windings and bushings are to be as direct as possible and phases should NOT cross over.

i) All instruments with alarm/trip contact or some form of information feedback shall be wired to the Instrument termination box. Cabling shall be overall and individually screened, be oil resistant and be routed in galvanised conduit (of at least 20 mm diameter). The conduit shall be mounted neatly with matching saddles and be routed to minimise cable length and the number of bends required.

3.2.4 Transformer Oil

The transformer shall be provided and delivered with the required quantity of insulating oil. The transformer oil shall comply with the requirements of SANS 555.

3.2.5 Oil-level Gauge

Oil-level gauges shall be flush-mounted with the gauge glass securely attached to the tank throughout its length by means of a metal shroud. Unprotected glass tubes are not acceptable.

3.2.6 Buchholz Relay

a) Buchholz relay shall be of the double float or bucket type and shall be of approved before manufacture.

b) The gas release cock for the relay shall be placed within easy reach from ground level and connected to the relay by small-bore non-ferrous tubing. The sight window of the relays shall be readily visible from ground level. The relay shall be fitted with tripping and alarm contacts to give off alarms associated with gas accumulation, pressure surges and low oil levels. It shall be so designed that the relay can be mechanically operated for testing purposes.

3.2.7 Silica-gel Breather

Silica-gel breathers shall have a window for inspection of the condition of the silica-gel and oil cup or other device to prevent continuous contact of the silica-gel with the air outside the transformer.

3.2.8 Neutral Earthing

Neutral earthing shall be as indicated elsewhere in the technical datasheets.

3.2.9 Bonding and earthing terminals

a) Earthing shall comply with SANS 780 clause 8.18. Two suitably rated main earthing terminals or clamps, welded to the transformer frame, shall be provided, preferably as close as possible to the primary and secondary conductor termination points. All conductive parts of the transformer assembly shall be galvanically connected to this terminal. For installations that are specified to be EMC compliant, bonding conductors internal to the transformer enclosure, as well as external conductors, should be of solid rectangular or braided construction instead of round conductors.

b) Earthing of control and measuring equipment, where they are to be provided, shall be in accordance with NRS 083-2 and IEEE 525.

3.2.10 Mechanical Strength and Construction

a) Transformers shall be of robust manufacture adequately designed and manufactured to withstand electrical fault forces and normal mechanical forces experienced in transport, installation, operation and removal.

b) Particular attention shall be paid to all core clamping arrangements.

c) The minimum plate thickness to be used for any purpose (e.g. cable box, cover) shall be as detailed in the Technical Datasheet.

3.2.11 Lifting Lugs

Lifting lugs shall be provided in accordance with SANS 780. The lugs shall have an inherent safety factor as described by the OHS Act.

3.2.12 Tap Changer

3.2.12.1 Off-Load tap Changer

a) The tap changer shall comprise an externally operated off-circuit switch with positive indication and padlocking facilities and shall be operable from ground level. The mechanism shall be of heavy-duty robust construction.

b) The tap positions shall be clearly and durably labelled and a sign shall be fitted that warns against on-load operation. This label shall be made of the same material as the diagram and name plate of the transformer, with the exception that the background shall be red with black letters.

c) The external tap positions shall correspond with the internal tap change positions to ensure optimal contact pressure. Alternative to a tap changer, bolted links shall be provided.

3.2.13 Power Cable Termination Boxes

a) Power cable termination boxes are to be manufactured from minimum 5 mm thick plate and are to have adequate air clearances for the specified voltage levels, i.e. phase to phase and phase to earth clearances shall be for open live connections as seen in table 5 of IEC 60076-3.

b) Cables to be accommodated will be according to the Technical Datasheet.

c) The height of the terminations shall not exceed 1 500 mm from ground level.

d) Where single core cables are specified the gland plate(s) shall use non-magnetic materials such as aluminium or brass.

e) The gland plate/section of the cable box is to be flat, with no lips protruding inwards to hinder gland affixing. The gland plate shall be a bolted removable plate.

f) Where specified, these power cable termination boxes shall be fitted with Arc Flash sensors integrated to the Arc Flash Relays.

3.2.14 Welding

All welding is to be of a recognised standard, suitably cleaned and ground to present a neat appearance and of adequate mechanical strength to withstand without damage the forces/pressures caused by internal faults.

3.2.15 Axles and Wheels

a) The transformer shall be supplied with acceptable bi-directional wheels.

b) The summated distance between the four wheels and the chassis of the transformer (measured from the outer sides) shall not exceed 1,000 mm.

c) The distance between the two axles shall be approximately 90 % of the length of the transformer tanks, but shall be designed by the Contractor to prevent any form of instability due to the assembly being “top heavy”.

3.2.16 Dial-Type Thermometers

Two thermometers are to be used. The one will be a winding thermometer which uses a dedicated Current Transformer (CT) to measure the temperature of the transformer windings. The second will be an oil thermometer which will be used to measure the oil temperature at the top of the tank. Both thermometers will have adjustable contacts for alarm and tripping purposes. The units are mounted on the side of the tank and the P100 sensors are in dedicated pockets in the top plate and the tubing is secured to a 20 mm rod acting as a support along the way. They will be strapped with cable ties and the contacts are to be wired to the marshalling kiosk. The thermometer shall comply with IEC 60076. The technical datasheet gives the specifications of the thermometer.

3.2.17 RTD Type Temperature Transmitters

A Resistance Temperature Detector (RTD) type head-mounted temperature transducers complete with RTD and head shall be fitted in a Thermometer pocket. This instrument shall be wired to the Instrument Termination Box.

3.2.18 Alarm and Trip Contacts

a) All alarm contacts shall be suitable for making or breaking up to 20 VA in compliance with the requirements.

b) All trip contacts shall be suitable for making and carrying, for half-a-second, a current corresponding to 150 watts at the specified alarm and tripping voltage.

c) Any auxiliary relays associated with trip circuits shall be DC operated and suitable for the specified alarm and tripping voltage.

d) Alarm and trip contacts shall be provided with electrically independent and ungrounded circuits.

3.2.19 Marshalling Kiosk (for Instrumentation and termination) and Cabling

a) Instrument cable termination boxes are to be manufactured from minimum 5 mm thick plate and are to have adequate working space to accommodate all instrument terminations and cabling. All instrument wiring shall be connected to DIN rail terminations.

b) The DIN rail length must provide sufficient space for 6 additional terminals for future use. All control/instrument terminals shall be knife-disconnect type Cage Clamp, suitable to take a stranded or solid conductor of not less than 4,8 mm diameter. Terminals of the type where clamping screws are in direct contact with the wire are not acceptable.

c) The height of the terminations shall not exceed 1,500 mm from ground level.

d) The Arc Flash Relays wired from the sensors in the Power Cable Termination Boxes will be installed in the Instrument Termination Box on a DIN rail.

e) The termination box cover shall be hinged and sealed to provide IP 65 to SANS 60529. It shall be lockable with a three point locking mechanism accepting a padlock. It shall be labelled as Instrument Termination Box. Hinges and locking mechanism lever to be from Stainless Steel.

f) The gland plate/section of the cable box is to be flat with no lips protruding inwards to hinder gland affixing. The gland plate shall be a bolted removable plate.

g) All cabling wired to the marshalling kiosk will be:

i) Underground Application – Non-halogenated, low smoke, low fume, flame retardant (White stripe)

ii) Surface Application - PVC (Red stripe)

3.2.20 Sound Level

a) During the design and manufacturing stage of transformers, care shall be taken to limit transformer noise and vibration to the level at present being attained in good practices. The transformer sound levels set out in SANS-IEC 60076 must be used as guideline.

b) If they are specified to be supplied, the selection of anti-vibration pads must take into consideration the influence of the supply frequency as well as expected harmonic values.

3.2.21 Rating Plates and labelling

All rating plates and labelling shall be made of aluminium and be engraved with black letters on normal aluminium colour background.

3.2.22 Surge Protection

Surge arresters are to be mounted inside cable boxes and connected to the transformer bushing and to the transformer main earth body to ensure direct and effective earthing. Surge arresters shall provide effective surge protection for the transformer MV and LV windings from all surges emanating from the electrical network due to lightning, switching, faults, etc.

3.2.23 Transformer Enclosure

a) The transformer, in its enclosure, shall be supplied with a longitudinal skid underbase and hauling eyes.

b) No aluminium material or aluminium rivets shall be used in the construction of the enclosure.

c) Painting of the enclosure shall be as per the specifications in the Technical Datasheets and shall comply with all the relevant standards.

4. QA REQUIREMENT

4.1 General

4.1.1 Quality of the complete assembles of the distribution transformer shall comply with the Engineering Standard SPE-EE-0001 'General Specification'.

5. TESTING AND COMMISSIONING

5.1 General

5.1.1 Testing of the transformer shall comply with the specifications as set out in the Standard Specification SPE-EE-0002 'Training, Testing and Commissioning'.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Medium Voltage Cables

25 June 2015

Revision: 0

Reference: EP-0042

Leading. Vibrant. Global.
www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title		Medium Voltage Cables				
Document ID		EP-0042	**Reference number**		EP-0042	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
1	25 June 2015	First Issue	M Kriel	ACJ Lombard	JJ Hattingh	AJ Zwiegers
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Adriaan Lombard	**Name**	Andries Zwiegers
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

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 Medium cable systems.

1.2 Electrical System Characteristics

1.2.1 The operating conditions of the electrical system to which the switchgear will be connected are as stated in the Project Specification.

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) 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: Standards

Standard Number	Description
NRS 028	Cable Lugs and Ferrules for copper and aluminium conductors: Preferred requirements for applications in the Electricity Supply Industry
NRS 075	Mechanical torque shear connectors for medium voltage applications
SANS 97	Electric cables - Impregnated paper-insulated metal-sheathed cables (PILC) for rated voltages 3,3/3,3 kV to 19/33 kV (excluding pressure assisted cables)
SANS 876	Cable terminations and live conductors within air-filled enclosures (insulation co-ordination) for rated a.c. voltages from 7,2 kV up to and including 36 kV
SANS 950	Unplasticized polyvinyl chloride rigid conduit and fittings for use in electrical installations
SANS 1019	Standard voltages, currents and insulation levels for electricity supply
SANS 1213	Mechanical cable glands
SANS 1339	Electric cables - Cross-linked polyethylene (XLPE) insulated cables for rated voltages 3,8/6,6 kV to 19/33 kV
SANS 1507	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V)
SANS 1803-1	Lugs and ferrules for insulated electric cables Part 1: Copper conductors
SANS 10142-2	The wiring of premises Part 2: Medium-voltage installations above 1 kV a.c. not exceeding 22 kV a.c. and up to and including 3 000 kW installed capacity
SANS 10198-1	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 1: Definitions and statutory requirements
SANS 10198-2	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 2: Selection of cable type and methods of installation
SANS 10198-3	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 3: Earthing systems - General provisions
SANS 10198-4	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 4: Current ratings
SANS 10198-5	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 5: Determination of thermal and electrical resistivity of soil

Standard Number	Description
SANS 10198-6	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 6: Transportation and storage
SANS 10198-7	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 7: Safety precautions
SANS 10198-8	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 8: Cable laying and installation
SANS 10198-9	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 9: Jointing and termination of extruded solid dielectric-insulated cables up to 3,3 kV
SANS 10198-10	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 10: Jointing and termination of paper-insulated cables
SANS 10198-11	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 11: Jointing and termination of screened polymeric-insulated cables
SANS 10198-12	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 12: Installation of earthing system
SANS 10198-13	The selection, handling and installation of electric power cables of rating not exceeding 33 kV Part 13: Testing, commissioning and fault location
SANS 6281-4	Test methods for impregnated paper-insulated electric cables Part 3: Tests on finished cable
SANS 61238	Compression and mechanical connectors for power cables for rated voltages up to 30 kV(Um = 36 kV)

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 The type of cable(s) to be used for the electrical installation shall be as specified in the Particular Specification. The conductor shall either be copper or aluminium as specified in the Particular Specification. All Medium Voltage cables that are used for an electrical installation shall comply with the requirements of the respective standards as follow:

a) SANS 97 for Paper-Insulated Lead Covered (PILC) cables; and

b) SANS 1339 for Cross-linked Polyethylene (XLPE) cables.

4. JOINTS AND TERMINATIONS

4.1 General

4.1.1 All Medium Voltage joints and terminations shall be done according to SANS 10198-10 and SANS 10198-11. All accessories required for these shall be installed according to the manufacturer's instructions and SANS 10198-10 and SANS 10198-11. Any Medium Voltage jointer shall be trained and qualified according to SANS 10198-10 and SANS 10198-11, with the necessary documentation submitted to the Engineer.

4.1.2 A moisture test shall be carried out in accordance with SANS 6281-4, on the outermost and innermost papers on each core of a PILC cable, prior to the making of any joints or terminations. If the results show that moisture is present in the paper, the cable shall be cut to where it is dry. If the complete cable is wet, it shall be removed and replaced.

4.1.3 No jointing or terminating shall commence in rainy weather without the prior approval of the Engineer. When the jointer commences with a joint he/she shall complete the joint before he/she leaves the site.

4.2 Cable Terminations

4.2.1 All the ends of the conductor shall be connected at the point of termination.

4.2.2 Termination of cables shall be by lugs jointed to the cable by an exothermic welding process, by crimping or by compression joints complying with SANS 61238.

4.2.3 Where holes are drilled in copper tape for connection to items of plant, the effective cross sectional area of the connection shall be maintained.

4.2.4 Surfaces of all equipment to which protective conductors are connected shall be clean, and free from paint and other non-conducting material. Surface preparation shall be removed at the point of contact, with the exception of galvanised or similar metallic preparations. Any surface preparations removed, shall be made good upon completion of the connection to preserve the life and purpose of both the surface and the protective conductor.

4.2.5 The standard phase arrangement shall be observed when connecting up cables in the end boxes. The Contractor shall ensure that the prescribed phase arrangement is at all times maintained on the external terminals of the boxes.

4.2.6 Terminal bodies and screws shall be constructed from non-corrosive metal, enclosed in fire resistant, moulded plastic, insulating bodies. No part of the terminal body or fastening screws shall project beyond the insulating material, which shall afford suitable protection against accidental contact by personnel and against short circuits or tracking.

4.2.7 The terminal block and its associated mounting rail shall be constructed in such a manner as to ensure a firm and positive fastening of the terminal block to the rail. Terminal blocks shall be held in position by means of standard end clamps. It shall furthermore be possible to extend the terminal block by adding additional terminal blocks within the terminal sequence without having to disconnect or dismantle the terminal strip.

4.2.8 It shall be possible to inter-mix terminals of various sizes, for different conductor sizes, whilst utilising the same mounting rail. Where smaller terminal blocks occur adjacent to larger terminal blocks, suitable shielding barriers shall be inserted to conceal the terminals that might otherwise be exposed.

4.2.9 The terminal bodies and clamping screws shall be constructed so as to ensure that conductors are not severed when the clamping screws are tightened. The screws shall not come into direct contact with the conductors.

4.2.10 Each terminal block shall have provision for clip-in numbering or labelling strips to be installed, together with protective, clear caps over the sheets.

4.2.11 The insulation of conductors shall only be removed over the portion of the conductors that enter the terminals of switches, socket-outlets or other equipment. When more than one conductor enters a terminal, the strands shall be securely twisted together. Under no circumstances shall any of the strands be removed to enable easier insertion of the conductors into terminals.

4.2.12 No more than two conductors shall be permitted to be fastened to any one terminal.

4.2.13 The Contractor shall take care to ensure that the copper strands are not damaged during the removal of the insulation.

4.2.14 PVC insulated conductors shall not be used for the direct connection to equipment where the temperature exceeds 75°C, such as stoves, geysers, electric water heaters and high power incandescent lamps. Silicon coated or other Engineer-approved cables shall be used in such cases.

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

4.3 Cable Joints

4.3.1 The Engineer shall be informed in advance of when jointing is to take place to enable him to inspect the joint.

4.3.2 The jointer shall, before he commences with the jointing, ensure that:

a) He has sufficient and suitable material to properly complete the joint;

b) The joint chamber is dry and clean;

c) The walls and sides of the joint chamber is firm and free of loose ground, stones, gravel, etc. which could fall into the chamber;

d) The necessary barriers are made to keep water out of the joint chamber;

e) The necessary cover is provided over the joint chamber to keep unexpected rain out of the chamber and that enough light and ventilation is provided under the cover;

f) The jointer has the necessary material to seal off the joint or termination when he has to discontinue jointing or terminating the cable due to unexpected storms or flooding of the chamber which makes it impossible to continue jointing or terminating the cable, irrespective of how far the work has commenced;

g) He has the necessary ground sheets to line the floor of the joint chamber;

h) The cable and other materials are dry, undamaged and in all respects suitable for jointing or terminating; and

i) The jointers equipment and tools are at all times dry and clean.

j) The Contractor is responsible to ensure that all the requirements are carried out by his jointer.

4.4 Glands

4.4.1 All metallic cable glands shall comply with SANS 1213 and PVC glands shall comply with SANS 10142-1.

4.4.2 Glands shall be suitable for the type and size of cable being installed and the intended operating environment. Where cables could be subjected to a wet or damped environment, water tight seals shall be fitted on inner/outer sheaths. All cable glands shall be fitted with an overall neoprene sealing sleeve.

4.4.3 Gland plates shall be a minimum of 2.0 mm thick and shall maintain the IP rating of the enclosure.

4.4.4 Where a cable is glanded through a painted or otherwise coated metallic surface, provision shall be made to ensure earth continuity between the gland and the enclosure.

4.4.5 Where single core power cables enter an enclosure aluminium or bronze glandplates shall be used to prevent circulating currents.

4.4.6 The cables shall be rigidly supported to ensure that the cables and glands enter the enclosure at 90º.

5. INSTALLATION OF CABLES

5.1 General

5.1.1 The installation of any cable shall comply with the requirements of SANS 10142-2, SANS 10198-2 and SANS 10198-8. Any site specific situation that is not covered in these standards shall be discussed with and approved by the Engineer. Cables shall be installed strictly in accordance with the cable route drawings.

5.1.2 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.

5.1.3 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.

5.1.4 Cables buried below ground shall, as far as possible, follow features of the site such as roadways and building lines.

5.1.5 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).

5.1.6 Cables and their support systems shall not be fixed to protective barriers, guards or directly to guard-rails.

5.1.7 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

5.1.8 Propriety (i.e. suited to and manufactured for such use) cable support systems shall be used.

5.1.9 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 Cable Route

5.2.1 The cable trench shall be excavated along the routes indicated on the relevant drawings and shall, as far as possible, follow features of the site such as roadways and building lines.

5.2.2 The trench shall be absolutely straight and shall comply with all requirements. The Engineer shall determine the length of the trench to be excavated, which shall not exceed 400 m, before the cable is installed and the trench backfilled.

5.2.3 If any obstacle or interference is encountered which may require alterations to the trench or cable routes, such alterations shall be approved by the Engineer.

5.3 Open-air Trenches

5.3.1 General

a) The proposed trench route shall be surveyed for the presence of underground cables and/or services before digging commences.

b) 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) Unless otherwise detailed on the drawings, the minimum depth required to the centre lines of cables or services shall be 1,000 mm.

c) 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.

d) Trenches shall be dug to within the dimensional tolerances given by SANS 1200, parts DB and LC.

e) Where the Contractor cannot excavate by means of machines, due to limited access and the proximity of other services, excavations shall be by hand.

f) 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.

g) The Contractor shall trim the trenches and clean up the bottom of the trenches after he has completed the required excavation.

h) 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.

i) No excavated material shall be left closer than 300 mm from the side of the excavation.

j) 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.

k) The Contractor shall maintain the excavation in a good condition, free of water, mud, lose ground, rocks, stones, gravel and other strange material until the cables are installed.

l) Prior to commencement of trenching, all “existing services” shown on the service drawings must be exposed by means of hand digging. This shall be done by labourers suitably skilled for this work.

m) Particular care must be exercised during all activities associated with excavations and labourers shall be fully alerted especially where “live” electric cables are to be exposed.

n) Particular care must be exercised not to damage other services when excavating in close proximity. Repairs to “known” existing services shall be for the Contractors account and shall be repaired with new materials and in accordance with acceptable and correct repair procedures, as approved by the Engineer.

o) Where other services must be removed by the Contractor, prior written consent of the Engineer is required. Care shall be taken not to damage the removed services. Any damage shall be reported to the Engineer.

p) Survey beacons or pegs may not be removed, altered or replaced by the Contractor. Where this is unavoidable the Engineer shall be advised in writing and appropriate action shall be taken at his instruction.

q) Beacons or pegs that are lost, removed or altered shall be replaced at the Contractor's expense.

5.3.3 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) Bedding and selected fill material shall consist of graded sandy soil that has a thermal resistivity of 1.2 Km/W.

c) 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 ouklip, peat and mine sand may not be used. The cost of importing shall be included in the price for the excavation.

d) The minimum thickness of the sand bed layer shall be 150 mm.

e) 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.

f) The cable shall, after the completion of the trench, be laid as soon as possible so that the trench can be backfilled.

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.

5.3.4 Laying of cables

a) Where cables are installed in trenches, they shall, after the completion of the trench, be laid with the minimum of delay so that the trench can be backfilled.

b) No cable shall be laid and installed without both of its ends sealed; hence each cable shall be properly inspected for sealed ends and possible damages prior to and after installation. Any damaged end caps shall be removed and replaced. Subsequently, each end of a cable shall be properly sealed if it is not yet installed. All cable ends shall remain properly sealed until such time when they are terminated.

c) Care shall be taken where cables are drawn into ducts, in order to ensure that they are not damaged by the ends of a duct. Once cables are drawn into the ducts, the ends of the ducts shall again be properly sealed.

d) At instances where two or more cables will run in the same trench, only one cable shall be installed at a time. The Contractor shall take precautions that the cables which are already installed are not damaged. Medium Voltage cables shall be laid in such a manner that the beginning of a drum shall be laid from the end of the previous drum to ensure that the lay of the cores remain the same.

e) Cables shall be laid such that they overlap at joints by at least 1 m, but not more than 1,5 m. Sufficient lengths of cable shall be left at the beginning and end of the cable routes to allow for the termination of the cables. Where necessary the Engineer shall decide on what length of cable is to be left.

f) 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.

g) 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.

h) The maximum tension on a cable during laying operations shall not exceed the value specified by the manufacturer.

i) 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.

j) Where cables are drawn through sleeves, care shall be taken that they are not kinked or excessively bent.

k) Cables shall all be buried 1,000 mm below finished ground level. The horizontal spacing between these parallel cables shall at least be 200 mm.

l) 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

m) 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.

n) The Engineer shall inspect all cable trenches before backfilling to ensure that the laying of cables complies with the specification.

5.3.5 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 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.

e) 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, 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.

f) All loose stones or any other materials likely to cause damage to cables shall be removed from trenches, before backfilling commences. Similarly, as per the requirements in SANS 1200 Part DB, any remains in the backfill material that is likely to cause damage to cables, shall be removed prior to backfilling. Care should be taken that all backfilling material consists of a graded soil and sand mix that has a thermal resistivity of 1.2 K.m/W.

g) Backfilling of trenches in road reserves shall be in layers not exceeding 150 mm and the use of a suitable compacting device is essential in order to achieve an approximate 93 % MOD AASHTO density.

h) Backfilling across properties shall be in layers of 300 mm with the use of correct facilities. Careful removal and prompt replacement of plants, shrubs, grass, etc. including care of subject matter until growth is re-established, is essential and must be allowed for in rates quoted. After completion of the work the route of the trench 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.

i) Where trenches are across or in a permanent walkway, pavement or gravel road, etc. it shall be reinstated such that the final topping is similar to the surrounding material.

5.3.6 Installation of concrete slabs

a) Concrete protective slabs shall be installed on bedding, approximately 100 mm above MV cables, and shall be approximately 300 mm wide and 50 mm thick. The slabs shall be constructed of 20 MPa concrete. Each slab shall be reinforced with two longitudinal and three transverses Y (reinforcing) mild steel rods having a diameter of 8 mm.

b) 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.

5.3.7 Electrical Warning Tape

a) All electrical cables shall be covered with a continuous brightly coloured electrical warning tape. The tape shall have an 800 gauge thickness. It shall be ensured that the warning tape covers all cables that are installed in a trench. Where two tapes need to be laid side-by-side, they will overlap by at least 10 mm.

b) The warning tape shall be installed 300 mm below finished ground level.

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) 45º, when all cables have a diameter less than 35 mm; or

ii) 22.5º , where any cable has a diameter greater than 35 mm.

e) All bends shall be of the long radius type.

f) LV cable sleeves will be adjacent to the MV cable ducts but towards the splay of the road.

g) All sleeves must be cleared by pulling through a loose fitting mandrel prior to the installation of cables.

h) After pipe sleeves have been installed by the contractor and before any backfilling may commence, a No. 10 gauge galvanised draw wire shall be left in the sleeve, prior to the ends of the sleeves being sealed by means of plastic plugs.

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) All sleeves used for road crossings shall be straight and undamaged. They shall be laid straight across a road at a depth of approximately 800 mm from the top of the duct to the finished surface of the road.

d) All sleeves shall protrude approximately 1,000 mm beyond the kerb line. Adequate precautions must be taken to ensure the correct compaction of ground layers with a maximum thickness of 150 mm, to avoid undermining of the road or kerb.

e) One extra sleeve shall be installed at each road crossing for possible future use.

f) Sleeves for MV cables shall be laid in a straight line with the proposed trench approximately 1 m from the property line.

g) 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.

h) The sleeves shall be laid straight to within the dimensional tolerances given by SANS 1200 part LC.

i) After installation, all foreign matter in the pipe shall be cleared.

j) The sleeves shall be sealed with PVC plugs to prevent the entry of sand before backfilling.

k) Precautions shall be taken to prevent damage to the sleeves during future construction activities.

l) 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 5º 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.

5.5 Joint Chambers

5.5.1 Joint Chambers shall comply with the requirements of SANS 10198-8. Special precautions must be taken at joints to ensure correct and secure support below cables and joints as well as for the subsequent backfilling.

5.6 Draw Pits

5.6.1 Where draw pits are to be constructed 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.

5.6.2 Draw pit covers shall be of cast iron manufacture, or as specified in the particular specification.

5.7 Protection

5.7.1 The Contractor shall take all necessary precautions to prevent trenching from being a hazard to the public.

5.7.2 The contractor shall safeguard all structures, roads, railways, other services, properties, etc., from any risk of subsidence and damage.

5.7.3 Trenches in front of occupied properties shall be closed by nightfall as far as possible or else suitable safe access must be provided for residents and vehicles. The trenches will be covered against accidental access.

6. MARKING AND LABELLING OF CABLES

6.1 Medium Voltage Cables

6.1.1 All medium voltage cables shall be properly labelled at both of its ends with stainless steel labelling plates. These labelling plates shall contain the following information:

a) The end termination point of the cable;

b) Voltage of the cable;

c) Type of cable;

d) Conductor material of the cable; and

e) Size of the cable.

6.1.2 Pyramid concrete markers shall be installed for the indication of Medium Voltage cable positions and cable joints. These markers shall be placed directly above the cable as follows:

a) At each change of direction in the cable run;

b) At each joint; and

c) Along straight cable runs with intervals not greater than 50 m.

6.1.3 Cable route markers shall be marked with “HT Cable” for any cable having a voltage higher than 1,000 V. An arrow on the cable route marker shall indicate the cable route.

6.1.4 Cable joint markers that are installed above Medium Voltage joints shall be marked as “HT Joint”.

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 10142-2.

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 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.

8.1.6 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.

8.1.7 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.

8.1.8 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 above the following tests shall be undertaken in the sequence listed as per SANS 10142-2:

a) Continuity of conductors

b) Resistance of earthing conductor

c) Continuity of the 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

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

General Electronic Installations

25 June 2015

Revision: 0

Reference II-0001

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						
Specification title		General Electronic Installations				
Document ID		II-0001	**Reference number**	II-0001		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the general requirements for the design, construction, supply, testing, installation and commissioning of Electronic Control & Instrumentation installations for Industry.

1.2 General Requirements

1.2.1 All Electronic Control & Instrumentation equipment shall be housed in dedicated control panels or enclosures conforming to the South African National Standard (SANS) for Control Gear as listed below.

1.2.2 The completed Assembly shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Project Specification and works or plant Control Philosophy.

1.2.3 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 follow an approved, auditable quality assurance system covering the design, construction, programming, configuring, 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 shall comply with the latest published edition of all relevant national standards, including the following:

Table 1 Reference Standards

SANS Number	Description
SANS 1973	Low-voltage switchgear and controlgear Assemblies
SANS 60204	Safety of machinery - Electrical equipment of machines
SANS 60439	Low-voltage switchgear and controlgear assemblies
SANS 61000	Electromagnetic compatibility (EMC)
SANS 61643	Surge Protection for Low-voltage AC and DC power supply systems, electronic systems, signalling systems and communication devices
SANS 62103	Electronic equipment for use in power installations
SANS 62305-4	Protection against lightning - Electrical and Electronic systems within structures
SANS 60950-1	Information Technology Equipment Safety - General Requirements
SANS 10142-1	The wiring of premises, Part1 - Low-voltage Installations

3. CONSTRUCTION REQUIREMENTS OF ELECTRONIC ASSEMBLIES

3.1 General

3.1.1 Electronic Assemblies shall be designed and constructed to facilitate inspection, cleaning, repair and maintenance and to ensure absolute safety during operation, inspection and maintenance. The Electronic Equipment manufacturer's requirements for enclosure cooling and ventilation of the equipment shall be adhered to at all times.

3.1.2 The arrangement of all circuit components / functional units shall be to the approval of the Engineer.

3.2 Enclosures

3.2.1 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.

3.2.2 All panels and enclosures 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 switch rooms or control rooms)	IP44 (doors closed) IP2X (inter-compartment & doors open)
Outdoor	Located outside of buildings in double clad outdoor weather proof enclosures	IP65 (doors closed) IP2X (inter-compartment & doors open)

3.2.3 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 maintains 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.

3.2.4 Particular attention shall be given to the ventilation of outdoor mounted boards, to eliminate build-up of excessive heat inside the boards caused by solar radiation or internal heat generation. If the internal temperature rise is within 20 % of the upper scale of the manufacturers specification for the equipment during any time of the day or year, panel coolers shall be provided as detailed in the project Specification.

3.2.5 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.

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

3.3 Construction

3.3.1 Free-standing electronic enclosures shall be constructed from steel with a structural frame permanently clad with side plates, so as to provide a structure that is rigid with all doors and covers removed, and such that it will not deform during transportation 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 The minimum metal thickness of the enclosure's constituent parts shall be as follows:

a) External cladding: 2.0 mm

b) Internal partitions: 1.6 mm

c) Doors: 2.0 mm

d) Gland plates and component mounting plates: 2.0 mm

3.3.3 Freestanding Assemblies shall be mounted on and bolted to a rigid hot-dip galvanised steel 100x50x6 mm channel iron base.

3.3.4 Wall mounted Assemblies shall be bolted to walls on concrete structures via a hot dip galvanise channel iron using spring nuts and washers with the channel iron bolted to the wall with concrete anchor bolts.

3.3.5 The maximum height of any Assembly (including its base) shall be 2100 mm above finished floor level. No equipment 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.

3.3.6 Enclosure single doors shall have vertical hinges mounted on their left hand side, be limited to 800 mm width, 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 may be hinged on the right hand side if this is beneficial to the room and equipment layout. Panels wider than 800 mm shall be fitted with dual doors that shall open in wardrobe style, such that the second door is interlocked with the first.

3.3.7 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 any electrical and earthing connections to components mounted on the doors. Compartment doors shall be provided with securing catches which can be locked with a padlock.

3.3.8 Doors shall include a full-length safety glass window with rubber gasket such that the internal electronic equipment status can be observed without opening the door. Where an HMI, pushbuttons, selector switch or indication lamps will be fitted to the door, the glass window will be placed below the equipment over the full remaining length of the door.

3.3.9 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; i.e. 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.

3.3.10 Fixings for components, component mounting plates, etc. shall not penetrate another compartment containing live parts. Only threaded fasteners shall be allowed and no components shall be fixed with rivets or self-tapping screws.

3.3.11 All 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.

3.3.12 All Assemblies shall make provision for have at least 15 % spare unequipped space complete with mounting rails and wire ways for future extensions.

4. INTERNAL WIRING AND FIELD CONNECTIONS

4.1 General

4.1.1 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 0.75 mm² cross-sectional areas.

4.1.2 Wiring shall be tinned if and as called for in the project Specification.

4.1.3 Field wiring connections will be identified 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 signal field terminations.

4.1.4 Wiring layout shall permit alterations to individual circuits without requiring shut down of the complete Assembly.

4.2 Wire ways inside Assembly

4.2.1 All wiring shall be routed in PVC cable trunking wire ways with snap-on covers and shall be sufficiently sized and properly placed in order to provide a neat and manageable internal wire routing system.

4.2.2 All wiring and cabling entering or leaving a compartment or passing through a partition shall do so via a permanently fixed PVC bush.

4.2.3 Wiring between components shall be:

a) carried out in a neat and systematic manner

b) contained in PVC trunking

c) run to panel doors in PVC spiral wrapping

4.2.4 Any wire containment system shall securely locate the wiring, and provide 25 % spare capacity on completion. Wire ways shall have furthermore sufficient space to enable the installation and removal of any wire without the need to remove any other wire, cable or component. Wire ways shall incorporate adequate facilities to locate and support the wires and cables.

4.2.5 Wiring on doors shall be similarly supported, and shall be provided with support and protection across the door to enclosure side wall transition, whilst permitting the door to be fully opened without straining the wiring. Wiring system accessories shall not be flame retardant and not deteriorate with heat.

4.2.6 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. Where lightning and/or surge protection measures have been implemented to protect individual circuits, these circuits shall be segregated from the wiring of other unprotected circuits.

4.2.7 Wire ways or chambers shall not contain any equipment or components.

4.2.8 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.

4.3 Gland Plates

4.3.1 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.

4.3.2 Gland plates shall be rigidly supported and maintain the IP rating of the enclosure.

4.3.3 Gland plates for bottom access cabling shall be located at least 300 mm above the finished floor level and shall be an integral part of the construction of the enclosure.

4.4 Identification

4.4.1 All wires shall be identified at both ends using colour coded alpha-numeric ferrules within a compartment.

4.4.2 Where a circuit includes a PLC I/O point, the I/O point identification shall follow through from the PLC card to the first component within a remote compartment.

4.4.3 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.

4.4.4 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.

4.4.5 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.

4.4.6 Circuit wiring shall be coloured in accordance with the clients requirements as detailed in the Project Specification.

4.5 Termination

4.5.1 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.

4.5.2 All wiring entering or leaving a compartment shall do so via screw type 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.

4.5.3 No more than two wires shall be connected to any one side of a terminal. Where it is necessary to connect adjacent terminals together, proprietary jumper bars or combs shall be used.

4.5.4 Spare cable cores shall be terminated at both ends or tied back, but shall not be cut short.

4.5.5 All terminals shall be protected to IP2X, including stud type terminals; which shall be shrouded to achieve this rating.

4.5.6 Terminals shall be segregated according to function and operating voltage; by grouping or by terminal rail mounted partitions or barriers and all circuit terminal rails shall include 10 % spare space.

4.5.7 Terminals shall face the compartment door for ease of connection.

4.5.8 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.

4.5.9 All wiring of external connections shall be brought out to individual terminals on a readily accessible terminal block.

4.6 Junction Boxes

4.6.1 Equipment and junction boxes shall be of steel, aluminium or GRP construction or as specified in the Project Specification.

4.6.2 All steel Junction Boxes shall be primed, undercoated and gloss finished with epoxy or polyurethane paint.

4.6.3 All boxes shall have a box name or number on the cover.

4.6.4 Junction Boxes for indoor use shall be at least IP 54 rated and Junction Boxes for outdoor use shall be at least IP 65 rated.

4.6.5 Junction boxes shall provide the facility to fully terminate the entire multi-core cable entering the box.

4.6.6 Junction Boxes which are exposed to the sun, shall be installed south facing otherwise with an additional shading cover.

4.6.7 Junction Boxes shall be mounted with their sides true vertical and horizontal.

4.6.8 Junction Boxes for instrumentation integral cables shall be of the round screw lid GRP or Aluminium type with two, three or four gland ports and shall be supplied fully equipped with screw terminals on a DIN rail inside and appropriate compression glands to fully gland and terminate the incoming and outgoing cables to maintain the required IP rating.

5. EARTHING

5.1 General

5.1.1 The complete electronic installation shall be earthed in accordance with the latest issues of the applicable South African National Standards (SANS) and any applicable bylaws of the local supply authority as well as any relevant client specific requirements as stipulated in the Project Specification.

5.1.2 The electronic installation shall incorporate a protective (power supply) earth system and a separate functional (instrumentation / data communications) earth system both of which shall be connected to the overall low-voltage installation's main earth system.

5.1.3 The Contractor shall familiarize himself with the Low-Voltage installation's earthing system at the plant or works (existing or installed by others) in order to tie the electronic earth system to the main earth system in compliance with the chosen earthing concept as defined in SANS 10142-1.

5.1.4 All functional earth conductors shall be insulated conductors providing a "clean earth" arrangement.

5.2 Earth Bars

5.2.1 Each Electronic Assembly shall include a separate protective Earth and functional earth bar. Earth bars shall:

a) be manufactured from high conductivity copper (tinned if and as called for in the Particular Specification)

b) be located in a safe and easily accessible position

c) have facilities for connection to the main incoming earth terminal (located in the LV switchroom / control room or at a local earth electrode system)

d) be rated and tested for the Assembly's expected maximum electrical supply fault current

e) be securely connected in each panel or cubicle with the protective earth bar bonded to the enclosure and the functional earth bar insulated from the enclosure

5.2.2 Provision shall be made for the connection of the following conductors to the fixed portions of the earth bars via drilled holes, cable lugs and fixing bolts:

a) electrical installation protective earth conductors internal and external to the Assembly

b) functional earthing conductors internal and external to the Assembly

c) equipotential bonding conductors internal and external to the Assembly

d) other equipment protective conductors external to the Assembly

e) an additional 2 off spare terminations

5.2.3 All metallic non-current carrying parts of the Assembly shall be bonded together and connected to the Assembly protective earth bar.

5.2.4 The following assembly parts shall be directly connected (bonded) to the protective earth bar by earthing conductors or braided straps with a minimum cross sectional area as defined in SANS 10142-1:

a) enclosure door (if it incorporates any equipment such as an HMI, pushbuttons, selector switches or indication lamps)

b) any removable electronic equipment covers

c) component / equipment mounting plates, rails and earth terminals

d) PLC / PCS and Instrumentation enclosure chassis plates

5.2.5 Surge protection earths; e.g. direct connections from lightning protection units. The following circuits shall be connected to the functional earth of the relevant assembly by earthing conductors with a minimum cross sectional area as defined in SANS 10142-1:

a) 'clean' earths from instrumentation circuits and equipment

b) functional earths; e.g. from telecommunications equipment

5.2.6 Each Assembly's earth terminals or bars shall be separately connected directly back to the Assembly main earth bar with earthing conductors of a minimum cross sectional area as defined in SANS 10142-1.

5.2.7 For installations that include control rooms or computer rooms (housing Information Technology and Telecommunications equipment), the functional earth shall consist of an earthing busbar and/ or earth mat as directed by the Project Specification.

5.2.8 Earthing busbar design and sizing shall comply with Annexure N of SANS 10142-1 and be rated as stipulated in the Project Specification and Technical Data Sheets.

5.2.9 Computer and Control Room earth mats shall be designed taking into account the expected equipment operational frequency ranges and equipment densities according to SANS 61000-5 Part 2.

5.2.10 Each Electronic Assembly in the Control or Computer Room shall be bonded directly to the earth busbar or earth mat via the shortest route and the earth busbar and/ or mat shall be separately connected directly back to the Assembly main earth bar, all with insulated earthing conductors of minimum cross sectional area as defined in SANS 10142-1.

5.2.11 If specified in the Project Specification, separate earth bars or studs shall be provided for connecting equipment requiring 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 an intrinsically safe earth, as directed by the intrinsically safe equipment supplier.

5.2.12 Where zener diode safety barriers are contained within an Assembly, they shall be separately and directly connected to the main earth bar via double earthing conductors; These conductors shall be clearly identified as intrinsically safe earths.

5.3 Earth Electrode

5.3.1 Where a protective Earth Electrode does not exist or has NOT been installed as part of the Low-voltage installation by others, this contract shall include for the supply and installation of a suitable main earth electrode as stipulated in the Project Specification and the Engineering Standard SPE-EE-0010 “LV and MV Earthing”.

5.3.2 A separate Electronic or “clean earth” electrode will not be accepted.

5.4 Earthing of Communication and Signal Cables

5.4.1 For the purpose of this specification, “communication” cables shall mean all data and network communication and transmission cables, and signal cables shall mean all instrument voltage or current loops and sensor cables.

5.4.2 The “common” or “reference” conductor of all signal cables shall be connected to the protective earth of the Electronic Assembly in order to ensure the safety of the equipment as well as the signal’s integrity.

5.4.3 Communications cables shall be connected to the functional earth to protect them against the negative effects of electromagnetic, inductive and capacity coupling so that noise on cables is limited to an absolute minimum preventing communication faults from occurring.

5.4.4 This shall be achieved by shielded (double screened) twisted conductor pair cables with the outer screen of all communication cables earthed with the aid of soldered termination and cable lugs at the source (electronic assembly) only. The route that the screened wire follows to the electronic assembly’s functional earthing point shall be as short as possible.

5.4.5 Where communications cables carry high frequencies (above 1 MHz) the screen shall be earthed to a parallel running functional earth conductor of minimum 2.5 mm^2 insulated copper conductor (or earth grid/ mat) in order to limit the effects of high frequency resonance.

5.4.6 When communications or signal cables 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 have their screens capacitively connected to earth as directed by the specific equipment supplier.

6. LIGHTNING AND SURGE PROTECTION

6.1 General

6.1.1 The complete Electronic installation shall be protected against transients, surges and induced interference from nearby electrical cables and / or equipment as well as mechanical equipment and related structures.

6.1.2 The protection shall ensure that the electronic equipment integrity is maintained and remains operational, or otherwise isolates the equipment from the transients, surges or interference in such a manner that it can be returned to operational use after the event.

6.1.3 Protection measures shall be provided as described below.

6.2 Earthing for Lightning and Surge Protection

6.2.1 The Lightning Protection System (LPS) shall be designed and selected to mitigate the expected lightning intensity on the site and as defined in the Project Specification.

6.2.2 Unless stated otherwise in the Project Specification, the Lightning protection system shall be assumed to be existing or installed by others under a separate Contract and the Electronic Assembly lighting protection measures shall tie into that system.

6.2.3 The Contractor shall familiarize himself with the system (existing or new) in order to tie into the system in the appropriate manner and as described in SANS 10142-1 and SANS 62305.

6.2.4 Proper bonding of all Electronic Assembly enclosures to the protective earth as described in Section 5.2 above, shall ensure protection against lighting induced electromagnetic surges impinging on the electronic assembly and all its internal components. All components supplied and installed within the Electronic Assemblies shall in any event be EMC compliant according to IEC 61000.

6.2.5 Proper shielding and bonding of communications and signal cable shields to the functional earth, as described in section 5.3 above, shall ensure protection against lighting induced electromagnetic surges impinging on data communications and signal cables to and from the Electronic Assemblies.

6.2.6 For the protection against lightning induced surges on power, communications and signal connections to and from the Electronic Assembly components, other assemblies and field devices, either isolation transformers, optical isolation, metal free fibre optic cabling or a system of coordinated surge protection devices (SPDs) connected to all conductors shall be used depending on the location of the equipment in the relevant lightning protection zones (LPZ), the expected surge intensities and the electronic equipment's impulse withstand ratings; all as defined in SANS 62305.

6.2.7 Where more than one SPD module is used at any one location or within any one Assembly, these shall be grouped together in one physical location.

6.2.8 The SPD modules shall be installed as close as possible to the Assembly's protective earth bar and shall be bonded to the protective Earth bar with a stranded copper conductor of minimum 6 mm^2 for Class II SPD (power) and 1 mm^2 for Class III SPD (signal and data).

6.2.9 Each surge protection module shall be individually connected to the earth bar using the shortest route possible.

6.2.10 All surge protection modules shall be DIN rail mountable and use screw terminals for termination of conductors.

6.2.11 All SPDs shall comply with the requirements of SANS 61643-1 and shall bear the SABS mark.

6.3 Surge Protection

6.3.1 The lightning and switching transients and the regulation of the available 230VAC supplies to the Electronic Assemblies shall be regarded as those relevant to an industrial supply.

6.3.2 The Tenderer shall therefore allow for additional surge suppression and voltage stabilisation equipment if this is required to protect his offered equipment and/or to guarantee its correct and reliable operation.

6.3.3 Equipment that is connected to signal lines of any type between separate LPZs shall, be surge protected to survive twenty 8/20 µs current impulses with maximum amplitude of 10 kA when applied in common mode between the signal lines connected together and to the system protective earth.

6.3.4 In the case where surge protection equipment is factory fitted into the electronic equipment being offered, but is found to be inadequate to meet this specification, additional external surge protection shall be provided.

6.3.5 Equipment which is connected to signal lines of any type between equipment within a common LPZ and for which the signal cable is longer than 30 m, shall be protected as above, except that the maximum amplitude for the common mode test shall be 2 kA and the maximum amplitude for the differential mode test shall be 500 A.

6.3.6 Surge protection devices shall be chosen in such a way that the protected circuit shall still function to specification in spite of the introduction of series and/or shunt impedances by the protecting devices.

6.3.7 Surge protection shall encompass, but not be limited to the following requirements:

a) On all analogue/digital input and output circuits - suitable signal surge protection units with appropriate ratings as defined by the relevant SANS 61643.

b) On all mains power supply circuits - suitable power supply protection modules as defined by the relevant SANS 61643.

c) On all telephone lines - Telkom approved protection network, containing gas arrestors, inductance's, transorb type arrestors and 600 Ω / 600 Ω isolating transformers. Loop and ringing current circuits shall be optically isolated.

d) Surge arrestors shall be installed on all phases of the electrical power supply at the input terminals to each equipment cabinet.

e) Where external lines have to interface with sensitive electronic equipment, such as computers and associated peripheral equipment, suitable opto-isolators with an isolation level of at least 5 kV shall be installed.

f) All co-axial cables shall be provided with in-line surge suppressors.

g) It is not anticipated that the stated equipment will, used on their own, necessary provide the required level of protection and the Contractor shall implement additional measures deemed necessary to achieve the required protection level.

h) The Engineer may allow the use of alternative types of surge arrestors, provided that equivalent or superior protection levels will be achieved. SABS and/or CSIR test reports to substantiate claims shall be submitted to the Engineer prior to installation for the alternative equipment.

i) The connecting cable between electronic units shall have a continuous screen (not bridged) which shall be earthed at both ends.

6.3.8 Power supply protection modules shall be used to protect the incoming power supply to the system and for mains supplied stations shall have the following characteristics:

a) The unit shall be rated to operate at a voltage up to 280V AC/DC.

b) The nominal discharge surge current (8/20 µs-wave) shall be greater or equal to 15 kA.

c) The maximum discharge surge current shall be greater or equal to 40 kA.

d) The unit shall react in less than 25 ns.

e) The unit shall be equipped with a visual indication to indicate a fault within the unit or if it is disconnected from the supply.

f) A fault within the unit shall not affect the operation of the power supply.

6.3.9 A power supply protection module shall be made up out of two units with the above characteristics the one unit connected between live and neutral and the other between neutral and earth. The earth shall be connected to the lightning protection interface earth bar via the shortest possible route and shall have a conductor cross sectional area of not less than 25 mm^2.

6.3.10 Signal SPD modules shall be of a pluggable design, with the decoupling elements arranged in the plug base element. The decoupling elements shall not be affected by the presence or absence of the protection plug and the removal of the protection plug shall not break the signal circuit.

6.3.11 It shall be possible to remove and test the protection unit on site using a portable test set.

6.3.12 Signal SPD modules shall be designed for two conductor floating ground circuits and shall offer individual signal line to ground as well as signal line to signal line protection.

6.3.13 The protection plug shall have the following basic elements and shall function as follows:

a) It shall be provided with a gas discharge tube that will absorb the largest part of the energy of an over-voltage impulse.

b) It shall be provided with a solid state Zener diode combination which will clamp the output voltage before the gas discharge tube is activated.

c) It shall be provided with diodes that will limit the capacitance between lines in order to limit the interference of high frequency signals.

6.3.14 The protection unit shall be able to contain over voltages to a maximum of 30 V AC peaks between any of the output terminals and earth or between the two output terminals.

6.3.15 Note: The over voltage referred to above, is defined as an over voltage with a rise time of 10 µs, a peak voltage of 800 V AC, a short circuit peak current of 100 Amp and a voltage down-time linear with a down-time of 50 % of the peak value after 100 µs. Such an over voltage is generally accepted in the telecommunications industry and represents the maximum energy and typical wave forms that are induced on twisted pair communications lines in the vicinity of lighting.

6.3.16 Copies of Type test certificates of the offered protection units shall be submitted to the Engineer for approval.

6.3.17 Terminal strip arrangement between RTU and field equipment shall be as follows:

a) Two separate terminal strips shall be provided, one for digital signals and one for analogue signals. The terminals shall be grouped per field device and secondarily by function (i.e. all inputs together and all outputs together per field device).

b) All digital inputs shall be powered by the electronic device's power supply and all digital outputs shall be field powered. All digital signals shall be protected by means of pluggable signal circuit protection units. The surge protection units shall comply with the relevant SANS 61643.

c) All analogue inputs will be field powered. All analogue inputs shall be protected by means of pluggable signal circuit protection units. The surge protection units shall comply with the relevant SANS 61643.

d) In addition to the above, all outgoing and incoming signal lines shall be protected by means of knife disconnect terminal blocks with gas-filled surge arrestors between signal lines.

e) The pluggable signal protection unit may serve as the terminal block for connecting outgoing cables.

f) All digital output signals shall be interfaced by means of interposing relays with a single pole change-over contact. The contacts shall be rated for a minimum of 2 A, 230 V at a power factor of 0,8.

6.3.18 The terminal arrangement as detailed above shall have at least 25 % spare space after all incoming cables (including spare cores) have been terminated.

7. SIGNS AND LABELS

7.1 General

7.1.1 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 or electronic system forming a part of the Assembly, and shall be provided for the specific identification of every component contained within the Assembly.

7.1.2 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

7.1.3 Signs and labels shall be securely and permanently fixed using an appropriate number of corrosion resistant, mechanical fixings (double sided adhesive tape will not be accepted). The fixing of labels, safety signs and notices shall not affect the IP rating of the Assembly.

7.1.4 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.

7.1.5 Safety signs and labels shall be of such size that the legend thereon is clearly legible from the operating position (or a 3 m distance), and the pictograph and its accompanying text shall be chosen so as to provide the appropriate communication in an explicit and unambiguous manner.

7.1.6 Safety signs and labels fixed to the outside of the enclosure shall be manufactured from 1.5 mm thick anti-reflective polycarbonate with the legend reverse screen printed, or alternatively from 3 mm 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.

7.2 Safety Signs

7.2.1 As a minimum, safety signs shall be fitted to removable covers over live connections, and to doors of compartments containing:

a) incoming supply cable termination points

b) functional units incorporating capacitors

c) hazardous equipment such as fibre optic laser communications

d) 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.

7.2.2 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.

7.2.3 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.

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

7.3 Labelling

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

7.3.2 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) IP rating

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

7.3.4 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 ("Traffolyte", "Darvic" or equal)

c) Reverse engraved acrylic material ("Perspex") with filled letters and reverse sprayed

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

7.3.6 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.

7.3.7 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: 8 mm

b) compartment designation labels: 6 mm

c) information or warning labels: 6 mm

d) component identification labels: 3 mm

7.3.8 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).

7.3.9 PLC / PCS and Remote Input / Output cards shall be fitted with printed I/O address labels including the TAG numbers where it is practical to do so. Alternatively a plastic laminated label card shall be provided and included in a steel pocket on the inside of the assembly door.

8. INSTALLATION REQUIREMENTS

8.1 Shipping

8.1.1 Assemblies shall be shipped in sections to facilitate field handling for transportation and installation. The shipped sections shall be joined together on site to form a complete unit assembly.

8.1.2 Preparation for shipment shall protect the Assembly auxiliary devices accessories, etc. against corrosion, breakage or vibration damage during transportation and handling.

8.1.3 All parts shall be clearly and permanently marked to facilitate disassembly and packing for transport. Instructions shall be provided for reassembly of sections on site or accompanied by a qualified representative from the Assembly Manufacturer.

8.2 Transportation and installation

8.2.1 The Contractor shall be responsible for disassembly, packaging, delivery to site (including loading and offloading) as well as reassembly of all equipment on site.

8.2.2 The Contractor shall provide timely information regarding all specialized handling and storage requirements for equipment to be transported and /or handled on the site until finally installed in the operating location.

9. FUNCTIONAL DESIGN

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

9.1 The Project Specification

The Project Specification detailing all project specific requirements.

9.2 Motor and Instrumentation Table

A Motor and Equipment List, and a Instrumentation list providing a list of all externally connected equipment, their function, rating and purpose. It provides the Engineer's estimate of each load's kW rating and the starting method, the process measurement, local visual indication and the requirements for manual, automatic and local control to be implemented.

9.3 I/O List

An I/O List detailing the Engineer's estimate of the input and output signals (analogue and digital) required for motor control, instrumentation and general control purposes.

9.4 Technical Detail Sheets

The Technical Detail Sheets used for Tender purposes, which shall be completed by the Contractor and verified by the Engineer for compliance to the Project Specifications, so as to detail the project and product specific requirements for each Assembly and its constituent functional units before procurement and manufacture.

9.5 Control Philosophy

The Control Philosophy detailing the Engineer's intent for functionality of the plant or works and all automation, control and instrumentation systems.

9.6 Cable Block Diagram

Cable block diagram(s) indicating how the components of the Assembly are to be connected to the motors and instrumentation for the process that must be controlled.

9.7 Assembly general arrangement drawing

A proposed layout providing the Contractor with the Engineer's intent for the layout and relevant sizing of the Assembly.

9.8 Building arrangement and equipment location drawing

A drawing indicating the plant layout, control equipment location and proposed location for the Electronic Assemblies.

9.9 Contractor's Design

The Contractor shall take the Engineer's design and complete it for the equipment offered during tender and approved for construction. Documentation and Drawings to be produced and submitted for approval are described in Section 10 below.

10. TESTING AND COMMISSIONING

10.1 General requirements for testing

10.1.1 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. All testing shall include both Hardware functional and Software simulation testing.

10.1.2 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).

10.1.3 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.

10.1.4 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 results have been recorded, and it has been signed off by the Engineer.

10.1.5 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.

10.1.6 The manufacturer shall ensure that all testing is carried out in a safe manner and shall be responsible for all measures in accordance with the Occupational Health and Safety Act.

10.1.7 During development, software may be electronically verified apart from the Assembly it controls 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 to equipment such as MCCs.

10.1.8 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.

10.2 Factory acceptance tests (FATs)

10.2.1 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.

10.2.2 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.

10.2.3 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.

10.3 Site acceptance test (SAT)

10.3.1 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.

10.3.2 During the SAT, all cables and terminations shall be subjected to continuity and short circuit tests.

10.3.3 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.

10.4 Commissioning and other tests

10.4.1 The Contractor shall ensure that the Assembly manufacturer provides assistance during the commissioning of the Assembly, whereby the functionality of the Assembly and its control system and software shall be proven. During commissioning the Contractor 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-Built' documentation and the Operating and Maintenance Manual, by the Contractor.

10.4.2 The Contractor shall provide a comprehensive commissioning checklist that shall be used to record the Electronic equipment and Control gear commissioning and tests results, and make provision for formal sign-off of the installation by the Engineer and the Client.

11. DOCUMENTATION AND TRAINING

11.1 General

11.1.1 All Assembly drawings, wiring diagrams, 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

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

11.2 Drawings for Approval by the Engineer

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

a) General arrangement, typical component mounting plate layouts, and foundation plans.

b) Wiring 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.

c) Software and configuration documentation; including logic diagrams and function block diagrams. 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.

11.3 Testing Documentation and Reports

11.3.1 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 the contractual documentation.

11.3.2 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.

11.3.3 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.

11.3.4 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.

11.3.5 The FAT and SIT shall each have been submitted and agreed with the Engineer, prior to the commencement of final testing and site commissioning.

11.4 Operating and Maintenance Manual

11.4.1 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.

11.4.2 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).

11.4.3 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 Built' 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 enclosure/ junction box / 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.

g) A DVD with all software backups and program code used on all data control devises (i.e. PLC, HMI, SCADA, control panels, industrial networks).

h) A schedule of all installed cables, with the following information:

   i) Tag number

   ii) From equipment tag number and description

   iii) To equipment tag number and description

   iv) Circuit number (DB name, circuit breaker e.g. DB01-CB08)

   v) Size

   vi) Installed length; and

   vii) Function (e.g. "Feeding Submersible pump IW-SP-01")

11.4.4 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 SCADA / telemetry systems, fault routines, etc. In other words, the FDS shall be converted to an FD to be inserted in the O&M Manual.

11.4.5 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.

g) Any interconnecting leads, protocol conversion modules, connectors, etc. necessary to connect and communicate with each programmable / configurable device to a standard portable Notebook.

11.4.6 The Manual format shall be A4 size with layout suitable for binding in A4 Level Arch type files. Drawings shall be A4 or A3 suitably folded to fit the A4 Lever Arch file.

11.5 Training

11.5.1 Electronic equipment operation and maintenance training shall form part of the overall training programme.

11.5.2 The Contractor shall conduct training courses for designated personnel in the maintenance and operation of the equipment and associated Assemblies.

11.5.3 The Assemblies shall be in a complete working order before training shall commence.

11.5.4 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.

11.5.5 Training and training manuals shall be based on the O&M Manuals.

11.5.6 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.

11.5.7 Where the Contractor presents portions of the course material by audio visual means, copies of those audio visual presentations shall be delivered to the Employer as part of the printed training manuals.

11.5.8 The Employer reserves the right to videotape the training sessions for later use.

11.5.9 The training shall include operator training and technical/maintenance training.

11.5.10 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.

11.6 Operations& Maintenance training sessions

11.6.1 There shall be training sessions for the operation and maintenance of the Assemblies.

11.6.2 The program for the training shall include instruction for at least one day per Assembly (8 hours) instruction on-site.

11.6.3 The program shall at a minimum cover the following:

a) General system overview

b) Functional operation of the system i.e.:

i) System start-up and shut-down procedures

ii) Equipment operation

iii) System access requirements

iv) Alarms

v) Fault Finding

vi) Backup Power Procedure (if applicable)

vii) Incident Reporting

viii) Maintenance

ix) Maintenance Schedule

x) Standard Maintenance Procedures

xi) Spare Part Lists

11.6.4 Upon completion of the course, the operators should be fully proficient in the system operation and have no unanswered questions regarding the system.

Aurecon South Africa (Pty) Ltd

1977/003711/07

Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441

PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Programmable Logic Controllers (PLC)

25 June 2015

Revision: 0

Reference: II-0002

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Document control						aurecon
Specification title	Programmable Logic Controllers (PLC)					
Document ID	II-0002		**Reference number**		II-0002	
File path	N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair
Current revision	**0**					

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the requirements for the design, construction, supply, programming, configuration, testing, installation and commissioning of Industrial Process Control equipment such as Programmable Logic Controllers (PLC) and Process Control Systems (PCS) as well as their interfaces to process equipment and instrumentation as well as to operator Visualization systems such as HMI and Supervisory Control and Data Acquisition (SCADA).

1.1.2 Where a package plant is offered with integral PLC or PCS this specification shall also apply and the onus is on the tenderer to qualify all deviations (if any) with his offer.

1.2 General Requirements

1.2.1 A PLC or PCS shall be provided for each area of the plant or works as listed in the Project Specification and as shown on the Control System Architecture diagram.

1.2.2 The PLC or PCS shall be provided complete with all components and peripherals necessary for it to completely control a plant or works and the architecture diagram defines the configuration of the PLC or PCS in terms of localization or centralization, local or remote inputs and Outputs (IO) and data communications interfaces, levels and paths.

1.2.3 The PLC or PCS shall be housed in a dedicated control panel or enclosure conforming to the South African National Standard (SANS) for Control Gear as listed in section 2.3 below and the Engineering Standard SPE-II-0001 - “General Electronic Installations”.

1.2.4 The completed Assembly shall incorporate all components and equipment necessary to reliably achieve the functionality defined in the Project Specification and Control Philosophy.

1.2.5 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 the Engineering Standard SPE-II-0001 “General Electronic Installations”, 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 follow an approved, auditable quality assurance system covering the design, construction, programming, configuring, 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

The PLC panel Assembly and all its constituent components, equipment, configuration and programming shall comply with the latest published edition of all relevant national standards, including the following:

Table 1: Reference Standards

Standards	Description
SANS	As listed in the Engineering Standard SPE-II-0001 “General Electronic Installations”
IEC 61131 (Parts 1-8)	Programmable Logic Controllers
IEC 61499-1	Function blocks
ANSI ISA-5.06.01-2007	Functional Requirements Documentation for Control Systems
ANSI ISA-6231-2011	Automation Systems Factory Acceptance Test (FAT), Site Acceptance Test (SAT), and Site Integration Test (SIT)

3. PLC HARDWARE

3.1 General

3.1.1 PLC and PCS hardware shall be of a recognised reputable type, approved by the Engineer; from a major international supplier, with a comprehensive and established South African based technical and logistical support operation.

3.1.2 The PLC / PCS shall comprise of the following:

a) Central Processing Unit (CPU)

b) dedicated Power Supply Unit (PSU)

c) digital and analogue hard-wired input / output (I/O) cards

d) remotely connected digital and analogue I/O cards (if and where specified)

e) data communications cards and/or ports on the CPU

3.1.3 The PLC / PCS shall interface with other devices and systems as follows:

a) control circuit components, equipment, instrumentation and plant devices

b) industrial Ethernet communications to Level 2 visualization and operation equipment

c) an open fieldbus communications to Level 0 equipment (if and where specified)

d) other process controllers (e.g. variable speed drives, electronic controllers, dedicated equipment control systems or other PLCs)

e) remote terminal units (RTUs), and telemetry systems

3.1.4 The hardwired I/O and network communication cards, together with the processor and power supply cards, shall all be housed in racks of one or more chassis units. Where chassis units are provided with spare slots for hardware expansion, these shall be protected by proprietary blanking plates. Any spare communications ports shall likewise be protected with dust covers or plugs.

3.1.5 The processor memory shall be sufficient to operate the as-installed programme with 20 % spare capacity, and the installed I/O cards shall be sufficient to operate the as-installed programme plus 10 % spare capacity of each I/O type used.

3.1.6 Once the program has been entered into the processor memory, it shall remain resident and unaltered, including under power down conditions, until it is deliberately modified by use of a programming unit. The processor shall contain a readily replaceable memory backup battery and indication of battery status.

3.1.7 The PLC / PCS shall be programmable using a standard portable notebook computer with suitable software as its programming device. The PLC / PCS shall be provided with all interfacing hardware and software; ready loaded and configured, to permit full access to the programme (including re-programming) via the standard serial communications port of a PC.

3.1.8 The processor shall incorporate the following indications as a minimum:

a) running

b) processor watchdog healthy

c) and I/O manipulation status

3.1.9 The processor watchdog signal shall be configured to raise an alarm upon CPU failure which shall be displayed on the associated HMI / SCADA or telemetry (where applicable).

3.1.10 The PLC / PCS CPU shall allow programme changes “on the fly”. In other words, minor changes to the control logic shall not require the CPU to be reset thereby causing the plant or works to be shut-down.

3.1.11 The PLC range shall offer various CPU memory, capacity, speed and I/O count sizes to suit the plant or works including “hot-standby”/ redundant CPU possibilities all as called for in the Project Specification.

3.2 PLC I/O

3.2.1 I/O cards shall be provided with voltages and signal loop currents (or voltages) as called for the in the Project Specification.

3.2.2 The I/O cards shall be keyed or otherwise configured to prevent maloperation if placed in the wrong position in a PLC / PCS rack, and each I/O card shall be capable of being individually removed or replaced without disturbing the wiring to adjacent cards.

3.2.3 Each I/O card shall be provided with an individually fused power supply feed, and an I/O card malfunction or power supply failure shall be recognised by the PLC hardware and software and raise an alarm on the CPU, relevant HMI or SCADA.

3.2.4 Conventional PLC I/O cards shall be limited to a maximum of 16 channels per card, and each I/O point shall be provided with an I/O status indicator. The use of 32 channel digital input cards will be subject to the card’s cable termination concept and approval of the Engineer.

3.2.5 The I/O wiring shall be segregated between input and output cards, and all I/O (including spare I/O) shall be loomed from the PLC card down to knife-edge (‘swinging blade’) disconnect type marshalling terminals from where these shall be marshalled to the field wiring. Where available, proprietary “looms” (connector / termination assemblies) shall be used to connect between the I/O card and the marshalling section.

3.2.6 Where it is necessary to maximise plant availability; e.g. with a duty / standby plant configuration, and more than one input card is available, the duty plant inputs shall be assigned to a separate card from the standby plant inputs. The same shall apply to the assignment of outputs to the plant.

3.2.7 Where mission critical applications require redundant IO these shall be accommodated by the choice of the PLC and appropriate CPU, and the circuitry shall be equally segregated as described above.

3.3 PLC Remote I/O

3.3.1 Where Remote I/O is called for in the Project Specification the I/O cards shall preferable be of the same type and range as those offered for the main PLC with centralised I/O.

3.3.2 Data communications from the PLC / PCS to Remote I/O shall be via a dedicated data communications medium and protocol specifically design for Remote I/O and the Data Communications medium from the PLC to HMI, SCADA or Field instrumentation may not be used for this purpose.

3.4 PLC I/O circuits

3.4.1 Digital input circuits, whether hard-wired to conventional I/O or connected via remote I/O, shall consist of volt-free contacts from control circuit components, equipment, and plant devices. These circuits shall be energised from the PLC end, and shall be “fail safe” in design, i.e. contacts shall open on PLC failure or alarm conditions and normal plant status conditions shall provide normally open contacts.

3.4.2 Digital outputs shall be provided with integral changeover relay contact suitably rated for the required switching duty, and shall be provided with suppression devices when switching DC loads. Alternatively, transistor output cards may be used in which case suitably rated interposing relays shall be included for each digital output in the Assembly.

3.4.3 Analogue input and output cards be capable of a minimum analogue to digital conversion resolution of 12 bits and shall include open circuit and short circuit monitoring.

3.4.4 Analogue inputs shall be powered either from the field instrument they connect to (where the instrument is separately powered with 230 V AC or 24 V DC), OR from a fused 24 V DC power supply at the PLC side where the instrument is loop powered. Each instrument loop circuit shall be designed for a loop impedance not exceeding 250 ohms.

3.4.5 Analogue outputs shall be powered from a fused 24 V DC supply via the analogue output card, and shall be able to drive into an impedance of up to 750 ohms. Analogue outputs shall provide a direct connection to the load (i.e. the whole primary loop).

3.4.6 Digital Inputs and Outputs shall be galvanically isolated in groups on no more than eight.

3.4.7 Analog Inputs and Outputs shall be individually galvanically isolated.

4. PLC SOFTWARE

4.1 General

4.1.1 PLC application software shall be written to meet the requirements of the plant or works Control Philosophy and the PLC processor shall be capable of being programmed using ladder logic, control system flow chart or statement list in accordance with SANS 61131-3. The software shall be laid out in a modular manner and structured in program and function blocks, such that similar tasks are of a similar structure and functionality to facilitate efficiency and ease of programming and maintenance.

4.1.2 Standard software Function Blocks shall be built up using the Client’s standard suite of function (when available), or the PLC manufacturer’s recommended standard Function Blocks.

4.1.3 Each line of code shall be fully documented and annotated, using mnemonics directly related to the associated item of plant. Function blocks shall be provided with descriptors e.g. analogue handling block, PID block, motor start block, etc. All data areas used shall be documented and a full memory map provided.

4.1.4 The PLC application software and operating data shall be held in appropriate memory locations; secured against power failure, and shall be provided with the facility for password protection against unauthorised access.

4.1.5 A sudden interruption of the power supply to the PLC shall result in the programme failing to a safe condition, and the PLC system shall not require manual attendance following a supply failure or restoration. The software control routines shall provide safe power-on and power-off sequences to ensure that the process is in a safe and controlled condition at all times.

4.1.6 Where a PLC forms part of a networked plant control system, it shall have a standalone operating capability such that in the event of a network failure it shall be able to continue monitoring and controlling its associated plant; using any set-points and parameters available prior to any network failure, including the ability for operators to change duties, monitor alarms, etc. via any associated local operator interface such as an HMI as called for in the Project Specification.

4.1.7 All software necessary to programme, operate, or maintain any equipment or component within the Assembly, including any network connectivity software, shall be provided, and shall be licensed in the Client’s name.

4.2 PLC software structure

The PLC application software controlling the plant shall be structured so as to provide, as a minimum requirement, the software routines for each key functional area as detailed in the following clauses:

4.2.1 Plant initiation

This key functional area shall contain routines developed to control plant start-up and restart, plant reset, and phased plant starting, after a power supply re-energisation; including a return to the control mode selected prior to powering down. Plant trips, when reset by the operator, shall reinstate normal automatic operation without the need for further operator intervention.

4.2.2 Plant automatic control

This key functional area shall contain all software necessary to provide automatic control of the plant process(es) and shall include alarm generation and exception handling, together with the starting-up and scheduling of any associated standby plant.

4.2.3 Plant shutdown

This key functional area shall contain routines developed to control plant shutdown, including under operational, power failure, and unplanned / emergency conditions.

4.2.4 Operator and remote interface(s)

This key functional area shall contain all software necessary to provide interfaces to the local HMI, and to SCADA or telemetry (where required). All digital points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate integer registers or memory areas, and all analogue points to / from the HMI, to / from the SCADA system, or to the telemetry system, shall be held within separate floating point registers or memory areas.

4.2.5 Interlocks

The PLC / PCS programming shall provide for two types of interlocks namely process and safety interlocks.

a) Process Interlocks:

   i) These are dictated by the physical flow of material through the plant and are typically programmed between motor, valve, actuator and controller software blocks.

   ii) Equipment being prevented from start-up by a process interlock shall clearly indicate this condition on the SCADA system.

b) Safety Interlocks:

   i) These are typically hardwired into the motor, valve or actuators control circuit, latched and reset in the MCC whilst monitored by the PLC and shall indicate as faults on the HMI or SCADA system.

4.3 PLC software control routines

4.3.1 The development of the PLC application software shall include as a minimum, the routines detailed in the following clauses.

4.3.2 For all plant items, the selection of automatic control via the auto-available input signal shall be recognised by the PLC and displayed at the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal). When an item of plant is selected for hand control, facilities for the rescheduling of any standby plant shall be provided.

4.3.3 Direct operator control via the PLC of each plant item (where that plant item is selected for automatic control) shall be provided from the associated HMI (and where appropriate, at a remote SCADA terminal). The selection of direct control shall leave the plant item state unchanged until a new control command is issued, at which time the rescheduling of any standby plant item shall take place.

4.3.4 Where duty / standby (or assist) plant is provided, the software control regime shall provide scheduling of these plant items through rotation of the duty / standby (or assist) functions. The duty rotation shall be dependent either upon the hours run for that item of plant selected for duty, or upon the issue of a manual duty rotate command. The required duty hours (between zero and 999) shall be entered by the operator at the associated HMI (or where appropriate, at a remote SCADA terminal). An entered value of zero duty hours shall inhibit the duty function within the associated plant item's duty rotation cycle. For those areas of plant where an apportioned wear pattern is required, an operator warning message shall be issued if the duty cycle hours entered for each item does not provide an uneven wear pattern. Where the operation of plant items is determined by upper and lower process limits, the automatic changeover of duty status shall be delayed until an appropriate point within the operating cycle.

4.4 PLC monitoring software

4.4.1 Monitoring software shall be provided to confirm the running of plant items in response to any start command, and shall use separately configurable time delays for each item of plant. If an item of plant fails to start within its configured time, the item of plant shall be deemed to have failed and an alarm shall be generated. The monitoring software shall also provide the accumulated run hours for all motor driven and proprietary items of plant.

4.4.2 When an item of plant fails, the control system shall automatically reschedule any standby plant item in place of the duty plant, and execute the appropriate shut-down sequence for the failed plant item. The standby plant item shall continue to operate in place of the failed duty plant item, until the plant item failure condition has been reset by the operator. Once the plant item failure condition has been cleared by the operator, the restored duty plant item shall operate and the standby plant item shall return to its standby status.

4.4.3 Monitoring software shall be provided to confirm the position of all valve(s) and penstock(s) in response to any open or close request, and shall use separately configurable time delays for each valve or penstock. If a valve or penstock fails to achieve the requested position, within its configured time, the valve or penstock shall be deemed to have failed and an alarm shall be generated.

4.4.4 Monitoring software shall be provided for the associated HMI, SCADA (and where appropriate, at a remote telemetry SCADA terminal), to generate operator message prompts where there is a need to manually exercise control over items of plant which remain in a static operating position or dormant state for extended periods of time. Where applicable, such plant will be identified in the Project Specification and / or Control Philosophy.

4.4.5 The PLC application software shall check all analogue input signals for validity. An analogue input signal shall be converted to a digital value at the I/O card, i.e. the current loop signal shall be converted to 0 - 4095 bits. The PLC software shall periodically check for a conversion which indicates under-range or over-range. If either of these two states is set, the software shall initiate an 'out of range' alarm.

4.4.6 In order to prevent the operator being presented with excessive spurious alarm messages, the PLC application software shall include routines, that on the initiation of a specific event alarm, shall prevent cascade alarms from being raised i.e. a 'mains failure' alarm will mask the 'not available' alarms from individual motor starters, valves, etc.

4.4.7 The PLC application software shall generate totalized quantities for individual items of equipment and instrumentation, whereby a pulsed digital signal shall be received and a set amount added to a totalizer register. The set amount used to increment the totalizer shall be adjustable and stored in a register. The totalizer shall be capable of the range 0 to 999999, and the totalizer shall automatically rolling over to zero when the maximum figure has been reached. The totalizer figures shall be displayed on the associated HMI display, SCADA (and where appropriate, at a remote telemetry SCADA terminal).

4.5 Functional Specification

4.5.1 Prior to programming the PLC or PCS, the Contractor shall provide the Engineer with a Control System Functional Design Specification describing how the Plant or Works Control Philosophy will be implemented in the Control System Software (PLC/ PCS).

4.5.2 The Functional Specification shall include at least the following:

a) Control System Overview

b) Final Approved plant or works Control Philosophy

c) Equipment, Motor and Instrumentation Lists

d) PLC IO lists

e) List of Interlock signals

f) List of Alarms

g) List of all PID control Loops

h) List of all Sequence and / or Duty/ Standby control

i) Detail description of PLC configuration and software building blocks (Function Blocks)

j) Function Block Parameters tables

4.5.3 The Functional Specification shall be issued to the Engineer for approval.

4.5.4 On completion of the contract the Functional Specification shall be converted into a Control System Functional Description and incorporated into the Operations and Maintenance Manuals.

5. INSTALLATION REQUIREMENTS

5.1.1 The PLC / PCS shall be installed in a dedicated enclosure conforming to the Engineering Standard SPE-II-0001 “General Electronic Installations”.

5.1.2 A separate Assembly shall be provided for each plant or works control area as called for in the Project Specification.

5.1.3 Each Assembly shall be physically located in the plant or works electrical load center(s) together with the associated Low Voltage Motor Control Center(s) (MCCs) OR in a dedicated centralized control room with remote IO at the MCC; all as called for in the Project Specification.

5.1.4 The installation, termination, earthing and lightning/ surge protection of the PLC/ PCS enclosure (and all associated components) shall conform to the requirements of the Engineering Standard SPE-II-0001 “General Electronic Installations”.

6. TESTING AND COMMISSIONING

The Controller Assembly(ies) shall be tested and commissioned as described in the Engineering Standard SPE-II-0001 “General Electronic Installations” with specific attention to the following:

a) During development, software shall be electronically verified apart from the process it controls using a simulation / diagnostic package.

b) The control systems shall be tested with the software loaded into the programmable devices, and with simulation of the physical I/O devices to equipment such as MCCs and Field Instrumentation and the Operator interface HMI and / or SCADA.

7. DOCUMENTATION AND TRAINING

Comprehensive documentation, training and operations & maintenance manuals shall be provided for each PLC / PCS Assembly provided for the plant or works under this contract, all as described in the Engineering Specification SPE-II-0001 “General Electronic Installations”.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Industrial Network Installation

25 June 2015

Revision: 0

Reference: II-0003

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:

a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control							aurecon
Specification title		Industrial Network Installation					
Document ID		II-0003	**Reference number**		II-0003		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD					
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**	
0	25 June 2015	First issue	M Kriel	K O'Kennedy	E Biesenbach	O Fair	
Current revision		**0**					

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Figures

Tables

1. SCOPE

1.1 Application

1.1.1 This Standard Specification defines the requirements for the design, construction, installation, inspection, testing and commissioning of Industrial Information and Communication Networks.

1.2 Installation Performance Requirements

1.2.1 The network installation shall be suitable for its intended duty with respect to data rate.

1.2.2 The network installation shall be suitable for the environmental conditions, particularly with respect to corrosion resistance and ingress protection.

1.2.3 The installation shall be suitable for its intended location, particularly with respect to the mechanical properties and impact strength of the components' parts.

1.2.4 The installation, including its circuit arrangements, shall satisfy the operational and functional requirements of the Employer and be readily and easily maintained throughout its operating life.

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 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 Manufacturer shall operate an auditable quality assurance procedure covering the design, construction, inspection and testing of the industrial information and communications network.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the Industrial Information and Communications Networks shall comply with all relevant Statutory Regulations and Directives including:

a) Occupational Health and Safety Act (Act 85 of 1993);

b) Manufacturer's specifications and installation instructions

and the latest editions (current at the time of Tender) of all relevant SANS, British Standards and International Standards, including:

Table 1: Reference Standards

SANS Number	Description
SANS 10142-1	Wiring Code
SANS 60793	Optical Fibres
SANS 60794	Optical Fibre Cables
SANS 11801	Information technology - Generic cabling for customer premises
SANS 61000	Electromagnetic compatibility (EMC)
BS 6701	Telecommunications equipment and telecommunications cabling - Specification for installation, operation and maintenance
BS EN 50174-1	Information technology - Cabling installation
IEC 61158-2	Industrial Communication Networks - Field bus specifications - Part 2: Physical layer specification and service definition

2.2.2 The installation shall also comply with:

a) This Specification including all Data Sheets; and

b) Any documentation issued by, or on behalf of, the Employer in respect of the Installation.

2.2.3 The Contractor shall operate an approved, auditable quality assurance procedure covering the design, construction, and inspection and testing of the Installation.

3. NETWORK INSTALLATION

3.1 All Networks

3.1.1 General

a) The Contractor shall be competent at Industrial Network installation. Competence shall be achieved by:

  i) Installation personnel having attended an approved Modbus/optical fibre network installer's course and passed all relevant examinations; or

  ii) Installation personnel having a proven track record of successful Modbus/optical fibre network installation on other similar projects; or

  iii) Other equivalent route approved by the Employer.

b) Installation shall comply with IEC 11801 and BS 7601.

c) The design of the Network shall comply with IEC 61158-2 - Industrial communication networks - Fieldbus specifications – Part 2: Physical layer specification and service definition; and IEC 50174-1 - Information technology: Cabling installation.

d) The network shall be standardised as far as possible to Modbus. Communication should either be via Modbus TCP or serial Modbus communication.

e) All cabling and equipment shall be labelled.

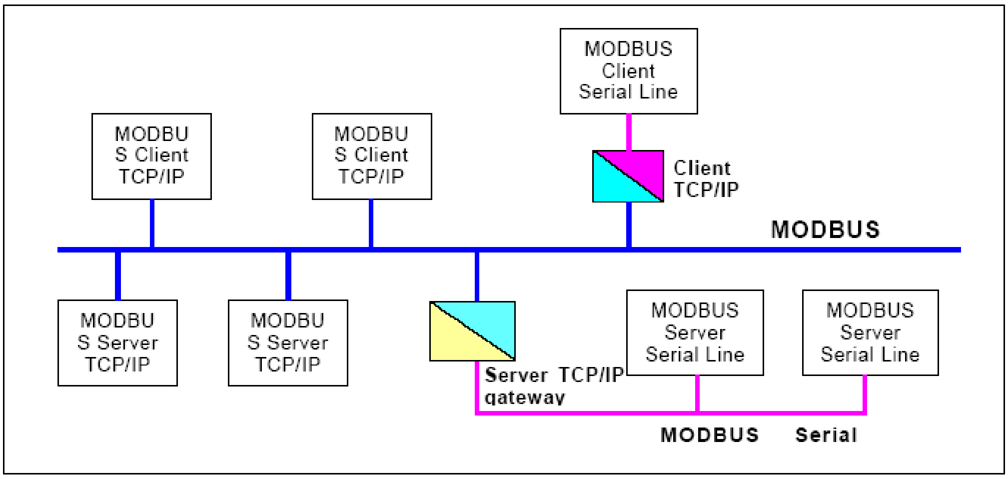


Figure 1: A typical Modbus Industrial Network (Source www.modbus.org)

4. MODBUS TCP/IP

4.1 General

4.1.1 All components in the Industrial network capable of communicating over Modbus TCP shall be connected to the communication network.

4.1.2 Components shall be configured in the most appropriate topology for the application.

4.1.3 The installation of the network shall be according to the Ethernet communication standards IEEE 802.3.

4.2 Copper Cabling Component Selection

4.2.1 General

All components shall be suitable for their intended duty, particularly with respect to the following:

a) The degree of ingress protection (IP rating) required.

b) The environmental conditions (particularly corrosion resistance).

c) The data rate/bandwidth should not be less than 10Mbits/s.

4.2.2 Copper Cabling

a) The cable shall comprise a shielded (STP) or unshielded (UTP), twisted pair cable of Cat 5 or Cat 6 as specified in the Particular Specification and Technical Data Sheets.

b) Physical layer shall be according to one of the following standards 10BASE-T, 100BASE-TX, or 1000BASE-T depending on the bit rate that is required.

c) Data cables shall be grey.

d) Copper cable runs may not exceed 90 meters, to allow for patch leads and fly leads.

e) If there is a significant likelihood of the cable being subjected to high mechanical stresses or attack by vermin during service and it is not practical to protect it by guards or other equivalent means, then the cable shall be armoured.

4.2.3 Connectors (If Required)

a) Connectors shall be suitable for the type of cable being installed and the type of device socket into which the cable will be connected.

b) All floor outlets must be of the RJ45 type.

c) The connector design shall ensure simple and effective connection of the cable cores and screen.

d) All connector pins and sockets shall, as a minimum, be flash gold plated.

4.3 Copper Cabling Installation

4.3.1 Cable Routing and Installation

a) The cable installation shall be according to BS EN 50174-1.

b) Cable routing/installation shall comply with the relevant parts of Engineering Standard SPE-II-0001 – "General Electronic Installations".

c) If network cables are routed underground, they shall be installed in ducts and not directly buried in the ground.

d) All bending of cables shall be in accordance with the manufacturer requirements.

4.3.2 Attaching Connectors to Cables

a) Connectors shall be attached to cables strictly in accordance with the connector manufacturer's instructions.

4.4 Fibre Optic Cabling Component Selection

4.4.1 Network Design

The usual approach in designing an optical fibre network shall be as follows:

a) Determination of the transmission path length.

b) Selection of the most appropriate type of optical fibre cable according to the required transmission path length.

c) Selection of suitable devices for the chosen optical fibre cable.

d) Selection of suitable connectors for the chosen devices.

4.4.2 Optic Fibre Cables

a) Cables shall comply with SANS 60793 and SANS 60794.

b) The fibre optic cable shall be single mode or multimode as specified in the Particular Specification and Technical Data Sheets. Unless otherwise stated multimode fibre shall be used for path lengths up to 550 m.

c) Unless otherwise stated in the Particular Specifications or Technical Data Sheets 2N redundancy (2 times the amount of cores that is needed) shall apply.

d) Physical layer for multimode fibre shall be according to one of the following standards 100BASE-FX, 1000BASE-SX, 10GBASE-SR, 10GBASE-LX4 depending on the bit rate that is required.

e) If there is a significant likelihood of the cable being subjected to high mechanical stresses or attack by vermin during service and it is not practical to protect the cable by guards or other equivalent means, then the cable shall be armoured.

4.4.3 Fibre Optic Cable Splicing

a) All splicing shall be of the fusion splice type and no mechanical splices are to be used

b) A maximum splice insertion loss of 0.3 dB per splice shall be allowed.

c) All fusion splices shall be done in splice enclosures of the correct type and size suitable for the environment and specific installation and shall have a warning label affixed unto the outside cover.

d) All splice joints shall have a splice protector over them.

e) All splice enclosures shall have a record sheet/label inside denoting the planning and use of the fibres according to colour coding and/or numbering. Furthermore, this shall be dated and labelled according to areas and/or signals in use.

4.4.4 Fibre Connectors

a) Connectors shall be suitable for the type of cable being installed and the type of device socket into which the cable will be connected.

4.5 Fibre Optic Installation

4.5.1 Cable Routing and Installation

a) Cable routing/installation shall comply with the relevant parts Engineering Standard SPE-II-0001 – “General Electronic Installations”.

b) Connector attached to pre-assembled cables shall be fitted with dust-protection caps (or equivalent protective measures) to prevent dirt/debris ingress during cable routing and installation.

4.5.2 Cable Routing and Installation

a) Connectors shall be attached to cables strictly in accordance with the connector manufacturer’s instructions.

b) Due to the potentially hazardous nature of fine glass fibres, all waste generated during assembly of glass optical fibre cables shall be removed from site and disposed of appropriately.

5. MODBUS OVER SERIAL LINE

5.1 General

5.1.1 Modbus over serial line shall be used where Modbus TCP communication is not viable, e.g. from PLC to Modbus enabled field instruments.

5.1.2 RS232 or RS 485 shall be used as physical interface.

5.1.3 RTU mode shall be the transmission mode.

5.1.4 The baud rate shall not be less than 19.2 kbs.

5.1.5 RS 232 interface should only be used for short length (typically less than 20 m) point to point interconnection.

5.1.6 For RS 485 either 2-wire or 4-wire configuration may be used.

5.1.7 Devices shall be connected to the trunk cable using spur cables and junction boxes.

5.2 RS 485

5.2.1 Topology

a) 32 Sevices are allowed on any RS 485-Modbus system without repeater. In practice the number of devices shall be limited to 25 to allow for:

i) Spare capacity for future installations

ii) The connection of diagnostic/programming equipment to the segment

b) The RS 485-Modbus configuration without repeater shall have one trunk cable, along which devices are connected directly (daisy chaining), or by short spur cables.

c) The length of the trunk cable shall be limited. The maximum length depends on the baud rate, the type of cable (Gauge, Capacitance or Characteristic Impedance), the number of loads on the daisy chain, and the network configuration (2-wire or 4-wire). The Contractor shall be able to submit prove that the length of the cable installed is indeed less than the maximum length for the specific installation.

d) The spur cables shall be short, never more than 20 m. If a multi-port tap is used with n spur lines, each one spur line shall have a maximum length of 40 m divided by n.

5.2.2 Earthing Arrangements

a) The Common circuit (Signal and optional Power Supply Common) must be connected directly to protective ground, preferably at one point only for the entire bus. Generally, this point shall be on the master device or on its tap.

5.3 Component Selection

5.3.1 Terminations

a) A reflection in a transmission line is the result of an impedance discontinuity that a travelling wave sees as it propagates down the line. To minimise reflections from the end of the RS485-cable, a line termination shall be placed near each end of the trunk cable. The termination shall comprise a capacitor and resistor in series connected between the cable cores.

b) It is important that the line be terminated at both ends since the propagation is bi-directional. More than two terminators shall not be placed.

c) Line terminations should not be placed on spur cables.

d) In RS232 interconnections, no termination should be wired.

5.3.2 Cables

a) The cable shall be a screened, twisted pair cable complying with IEC 61158-2.

b) A Modbus over Serial Line Cable must be shielded. At one end of each cable its shield must be connected to protective earth. If a connector is used at this end, the shell of the connector shall be connected to the shield of the cable.

c) An RS485-Modbus configuration shall use a balanced pair and a third wire (for the ground). In addition to that a second balanced pair shall be used in a 4 wire-Modbus system.

d) If there is a significant likelihood of the cable being subjected to high mechanical stresses or attack by vermin during service and it is not practical to protect the cable by guards or other equivalent means, then the cable shall be armoured.

e) For a RS485-Modbus the wire gauge must be chosen sufficiently wide to permit the maximum length (1000 m). AWG 24 is sufficient for Modbus Data.

f) Category 5 cables maybe used for RS485-Modbus, to a maximum length of 600 m.

g) For the balanced pairs used in an RS485-system, a characteristic impedance with a value higher than 100 Ohms shall be used, especially for 19.2 kbs and higher baud rates.

5.3.3 Junction Boxes

a) Each spur cable shall be connected to the trunk cable via a junction box (a single junction box may be used for connecting one or more spur cables to the trunk cable).

b) Junction boxes shall be suitable for their intended duty, particularly with respect to the following:

   i) Ingress protection (IP) rating;

   ii) Corrosion resistance; and

   iii) Impact strength.

c) The method of connecting the spur cable to the junction box shall be via an M 12 connection.

d) Junction boxes shall ensure uninterrupted bus operation when exchanging devices or extending spur cables.

e) Junction boxes shall incorporate a termination resistor that may be switched in or out, as required.

5.3.4 Connectors

a) Connectors shall be suitable for the type of cable being installed and the type of device socket into which the cable will be connected.

b) The following connectors shall be used:

   i) RJ45

   ii) 9-pin Sub-D connector

c) The connector design shall be ensure simple and effective connection of the cable cores and screen.

d) All connector pins and sockets shall, as minimum, be flash gold plated.

6. EARTHING AND EQUIPOTENTIAL BONDING

6.1 General

6.1.1 The network shall be provided with an effective earthing and equipotential bonding system to:

a) Ensure effective earthing of cable screens/devices, thus ensuring that electrostatic interference is diverted to earth as opposed to causing pickup in the device electronic circuits; and

b) Ensure that the earth potential is the same at all points across the network to prevent earth currents flowing through the cable screens.

6.1.2 To prevent electrical currents passing along the screens of cables connecting devices installed in parts of the network subject to different earth potentials (e.g. between different buildings etc.) one of the following measures shall be adopted:

a) The devices shall be connected together with an optical fibre cable; or

b) A potential equalisation cable shall be run alongside the network cable to equalise the earth potentials (refer to later Section, Potential Equalisation Cable).

6.2 Earthing of Cable Screens

6.2.1 At the Device

a) The cable screen shall be earthed at both ends of the cable i.e. at every device.

b) If connectors are used to attach the cable to its associated devices, the screen shall be earthed via the connector when the connector is plugged into the device (assuming the device is earthed). If connectors are not used, (i.e. for devices that require direct cable connection), the device shall incorporate suitable features/facilities for earthing the cable screen.

6.2.2 At the Assembly Entry

a) To prevent any outside interference (picked up by the cable) being transmitted into an Assembly, the cable screen shall be earthed at the point of entry of the cable into the Assembly.

b) To facilitate this connection, the Assembly shall be provided with an earthing rail at the Assembly entry behind the cable strain relief.

c) The large surface area connection between the cable screen and the earthing rail shall be achieved with an approved, proprietary screen connection clamp.

d) The following points shall be observed when making the earthing connection:

i) To avoid unnecessary weakening of the cable around the earthing connection, the outer cable sheath/insulation shall only be removed where required for earthing purposes;

ii) The earthing connection shall not be used as a strain relief since this may reduce its effectiveness and cause the cable screen to be damaged (an exception would be when using parts that are specifically designed for this purpose);

iii) To protect the weakened cable from damage, it shall be securely fixed to the Assembly either side of the earthing connection;

iv) The size of the screen connection clamp shall be accurately matched to the cable diameter to ensure that the screen is securely connected to the clamp without pinching;

v) The connection between the screen and the earthing system shall only be made using the braided screen. Many fieldbus cables feature a foil screen and this shall not be used to achieve the earthing connection;

vi) The earthing rail may be attached to galvanized or plated surfaces but not to painted surfaces; and

vii) All metallic components comprising the earthing connection shall be inherently corrosion resistant or otherwise be protected against corrosion to ensure that the earthing connection remains effective for the asset life of the network.

6.3 Earthing of Devices

6.3.1 Devices shall be earthed in accordance with the device manufacturer's instructions.

6.3.2 This shall normally be achieved via either:

a) The device earth terminal; and/or

b) The device mounting arrangement (i.e. bracket, rails or screws etc.).

c) Earthing connections shall be made using copper cables with an appropriate cross sectional area (> 2.5 mm^2).

6.4 Potential Equalisation Cable (If Required/Provided)

6.4.1 If there are large variations in earth potential at different points within the installation, connecting both ends of the cable screen to earth can lead to current passing along the cable screen; this current is to be avoided since it can lead to interference pickup.

6.4.2 This situation can occur if:

a) The network cable covers a large area or extends over a long distance;

b) Power is supplied to different sites from different sources (i.e. sub stations); and/or

c) Heavy electrical currents are present (e.g. arc furnaces, power stations etc.).

6.4.3 If there are large variations in earth potential at different points across the installation, a potential equalisation cable may be installed to equalise the earth potentials.

6.4.4 To ensure that the cable is effective at earthing high frequency signals, it shall be finely stranded with a large surface area.

6.4.5 The potential equalisation cable shall be laid parallel to and as close as possible to the network cable to minimise the area enclosed between the two cables. The cable may also be used as to provide protection against the effects of a lightning strike.

6.4.6 The potential equalisation cable can carry significant current and shall be sized in accordance with IEC 60364-5-54.

7. DRAWINGS AND DOCUMENTATION

7.1 General

7.1.1 Drawings and Documentation of the Industrial Network shall be required for the Control System Functional Specification as described in Engineering Standard SPE-II-0001 – "General Electronic Installations".

7.1.2 After completion of the network installation and before final commission, the Contractor shall provide the Employer with a set of 'as-built' network installation drawings and cable schedules, which shall form part of the Operation and Maintenance Manual.

7.1.3 Any changes made during Commissioning shall be incorporated into these Manuals.

7.1.4 The Drawings and Documentation that shall form part of the Operation and Maintenance Manuals is described below.

7.2 Drawings

7.2.1 Drawings shall be to a standard scale and be sufficiently detailed to serve the purposes of recording the Industrial Network installation.

7.2.2 Drawings shall, as a minimum, show the following details:

a) The general arrangement of all devices (i.e. masters, slaves, active terminators etc.) connected to the network;

b) The routes of all network cables with associated cable references;

c) Buried network cables and associated cable marker posts;

d) Cable ducts, draw pits and pre-cast service trenches, etc. utilised by the network;

e) All splice enclosure locations;

f) Earthing/bonding conductor routes and connections; and

g) The boundaries of any areas that have been classified as hazardous areas.

7.3 Cable Schedules

7.3.1 Comprehensive cable schedules shall be provided, detailing all cables, including earth cables, which are installed.

7.3.2 As a minimum, the following information shall be provided, per circuit, on each cable schedule:

a) Cable reference number;

b) Cable source and destination (including the compartment reference number in the cases of cables which terminate at multi-compartment motor control centres, etc.);

c) Route length; and

d) Method of installation.

8. TESTING AND COMMISSIONING

8.1 Installation Verification

8.1.1 General

Before the start of any network installation activities, the Contractor shall provide the Employer with details of any deviations from the proposed network design for approval.

8.2 Network Testing

8.2.1 Pre-Commissioning Testing of Installation and Wiring

a) Installation and wiring testing shall include the following activities:

   i) Visual checking of the cable specification, layout (spurs), routing, segregation, support and lack of damage;

   ii) Connector and termination wiring, termination check, correct use of in/out cable entry;

   iii) Wiring check for shorts, open circuits, crossed wire etc. (including screening);

   iv) Bonding and earthing, potential equalisation;

   v) Addressing check (duplicate addressing can be difficult to diagnose); and

   vi) Segment cable length check (can be done with analyser and scope) and device count check.

b) Following testing, the Contractor shall provide the Employer with a certificate of validation stating that the network is free of connection problems (i.e. crossed wires, screening faults etc.) and is correctly earthed etc. This certificate shall be accompanied by a schedule of all tests conducted from the PLC to each device including the reported cable length for each test. The final test shall be performed at the furthest device on the network to give an estimate of the overall network cable length. The schedule shall include a specific measurement of the length of any spurs incorporated at device connections, with a summation of the total spur length provided at the end of the schedule. In addition, a marked up and commented drawing indicating any changes to the original design shall be provided.

8.2.2 Commissioning Testing (Health Checking)

a) The network shall be subjected to Commissioning Testing (Health Checking) to check for interference and reflections etc. using an analyser and oscilloscope.

b) On a powered network, the Contractor shall undertake a diagnostic test to validate the active network as being able to operate at the design baud rate using an approved test device.

c) The certificate of validation shall be endorsed to state that the network can operate at the design speed, and that any reflections will not be detrimental to the operation of the network for the asset life.

8.2.3 Optical Fibre Testing

a) All terminated links shall be tested using a Power Meter and Light Source (PMLS) Tests, an optical time-domain reflectometer (OTDR) may only be used as an additional test. The tests shall include the full set of tests required to confirm performance to ISO/IEC 14763-3 specification.

b) The tester shall have a certification of calibration current to within the tester manufacturer's specification.

c) Multimode fibre shall be tested using the 3-jumper method. Testing shall be undertaken in both directions at 850 nm and 1300 nm.

d) Single mode fibre shall be tested using the 3-jumper method. Testing shall be undertaken in both directions at 1310 nm and 1500 nm.

e) Cable length shall be verified either by using an OTDR or it may be directly determined from the cable metre marking.

8.2.4 Dark fibre

a) All un-terminated links (dark fibre) shall be tested using an OTDR to verify fibre integrity and length. Connection to the OTDR may be made using a reusable mechanical splice incorporating index-matching gel or by OTDR accessories such as bare-fibre adapters.

b) Cable length shall be verified using either an OTDR or may be determined from the cable metre marking.

c) OTDR test may be undertaken in one direction and at one wavelength only confirming fibre integrity.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

aurecon

Engineering Standard

Supervisory Control and Data Acquisition

25 June 2015

Revision: 0

Reference: II-0005

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:
a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						aurecon
Specification title		Supervisory Control and Data Acquisition				
Document ID		II-0005	**Reference number**		II-0005	
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	K O'Kennedy	A Schröder	O Fair
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Figures

Tables

1. SCOPE

1.1 Application

1.1.1 This Specification covers the requirements for a Supervisory Control and Data Acquisition (SCADA) system.

1.1.2 The primary intention of this Specification is to ensure the delivery of a SCADA system which has been properly designed and constructed to ensure safe, reliable operation and is simple to maintain.

1.1.3 The scope of work shall encompass the following:

SCADA system: Design, supply, programming, delivery, installation, testing and commissioning of the required computer hardware, software and peripheral's constituting a complete and fully operational SCADA system including, but not limited to, the system functions as specified herein.

1.1.4 The exact system configuration and related equipment necessary for the complete installation, shall be as detailed in the Project Specification.

1.2 General

1.2.1 The following definitions are used in this Specification:

The term "SCADA" shall include the complete Supervisory Control and Data Acquisition system comprising of server computers, client workstation computers, database servers, engineering computers and all peripherals such as network switches, cabling, printers and power supplies.

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 Project Specification and its accompanying Technical Data Sheets, which shall be read in conjunction with this Standard 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.

2.2 Regulations, Specifications and Standards

2.2.1 The design, construction, inspection and testing of the SCADA and telemetry system 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 SANS, British Standards and International Standards, including:

Table 1: Reference Standards

Standard Number	Description
SANS 1063	Earth rods, couplers and connections
SANS 1091	National colour standards of Paint
SANS 10142-1	Wiring of Premises Part 1 : Low Voltage Installations
SANS 10199	The design and installation of earth electrodes
SANS 60529	Degrees of protection provided by enclosures (IP Code)
SANS 61643	Low-Voltage Surge Protection Devices
NRS 042	Guide for the protection of electronic equipment against damaging transients
Other	**Description**
ISA 5.5	Graphic Symbols for Process Displays
ISA 5.06	Functional Requirements Documentation for Control Systems
ISA 18.2	Management of Alarm Systems for the Process Industries

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.

2.2.3 The Contractor shall follow an approved, auditable quality assurance procedure covering the design, construction, and inspection and testing of the Installation.

3. SCADA

3.1 General

3.1.1 System Overview

a) The SCADA system shall form an integral part of the plant / works' automation system.

b) The system shall provide the Human Machine Interface (HMI) between the operator and the plant / works, providing for overall supervision, co-ordination, control (dynamic process adjustments), operations monitoring and recording.

c) The SCADA system shall be connected to and collect data from field devices (e.g. RTU's, PLC's and Process Instrumentation) and record these in a relational database.

d) The SCADA system shall communicate (via appropriate protocol drivers) with field devices using data transmission methods and equipment as specified in the Project Specification and Technical Data Sheets.

e) The data obtained and recorded by the SCADA system shall be available via a SCADA local or wide area network (LAN/WAN) to any local (or remote) computer SCADA workstations for visualization, trending and analysis purposes.

3.1.2 Functional Requirements

The SCADA system shall communicate cyclically with its field devices at all times and shall perform, but not be limited to, all functionality in this specification. The main functions of the SCADA shall be:

a) Process related data and measurement acquisition

This feature shall include the following basic functionality:

i) Process variables and measurement data collection and storage to a Relational Database Management System (RDBMS) according to predefined logging intervals.

ii) Discreet signal processing, for example Status messages (on/off), open/close, etc.), alarm and event disturbance logging.

iii) Analogue value supervision, e.g. Range supervision, min/max value supervision, calculations and conversion from engineering to real values for Monitoring SCADA Radio Telemetry systems only (RTUs). NOTE: Analogue value supervision, e.g. Range supervision, min/max value supervision, calculations etc. for process control SCADA shall be done in the PLC and NOT the SCADA.

b) Report generation

The SCADA reporting feature shall provide the following functionality, in the form of a screen display, downloadable file, as well as printable hard copy:

i) Daily reports

ii) Monthly reports

iii) Yearly reports

iv) Alarm and disturbance reports

v) Operator Messages and Alerts

vi) Maintenance reports

vii) On demand data query reports

c) Process visualisation

The process visualisation feature shall provide the following functionality:

i) Dynamic process symbols (images / mimics)

ii) Display of trend curves from historical data

iii) Display of trend curves on a real time basis

iv) Display of operator alerts, messages, alarms and events

d) Operator command interface

Process control commands, setpoints and parameter changes shall be allowed by the operator via SCADA faceplates and shall include:

i) Control system set points.

ii) Switching drives on/off, opening/closing of valves, etc.

iii) Acknowledgement of error and alarm messages

e) Operator Access Security

The system shall provide for an access authorisation (password) system, whereby different level of operators shall be granted different operational authorisation as detailed further below and stipulated in the Project Specification.

3.1.3 General Requirements

a) All operator commands and settings as well as process measured values and status data that is communicated to and from the remotely connected devices shall be represented by a unique “tag” or “point” within the SCADA system.

b) All process measurements shall be done on-line, such that the SCADA system can respond to changes in the plant or works in real time.

c) The SCADA system shall be capable of operating in a stand-alone or client-server configuration with the capability of having multiple users and multiple workstations working simultaneously on a common SCADA implementation.

d) All equipment (hardware and software) shall have a proven track record and shall have a large user and technical support base.

e) Where computer hardware is specified, it remains the Contractors' responsibility to ensure that the actual hardware offered and installed is adequate to support the offered SCADA software and the specified SCADA functionality, including future expandability.

f) All computer hardware shall be suitable for industrial use and shall have been either purposely designed for industrial use or shall have been thoroughly ruggedised for use in an industrial environment.

g) Computing devices shall be certified to comply with the applicable regulations for Electromagnetic compatibility of electronic and digital equipment in order to limit harmful interference (such as to and from radio equipment).

h) The operational state of the SCADA system shall NOT detrimentally affect the automation and control of the plant or works. i.e. If the SCADA system fails or needs to be restarted, the PLCs, RTU’s and Process Instrumentation shall continue operating the plant or works.

i) The complete SCADA system shall restart automatically when normal (or standby) power has been lost then restored (or re-activated).

j) All measured values and status data from the PLCs, RTUs and Process Instrumentation shall be buffered, retrieved and updated on the SCADA after an outage.

k) The SCADA system shall record the down time and in the event that data acquisition has failed and/ or failed to update missing data, shall flag the event and log the “downtime”.

3.2 SCADA System Hardware

3.2.1 General

a) The hardware specified in the Project Specification and Technical Data Sheets shall include all necessary components for a fully functional SCADA installation, whether specifically listed or not.

b) All hardware shall be rated for continuous operation under the environmental conditions stipulated in the Project Specification.

3.2.2 Computer equipment

a) The computer hardware form shall be as stipulated in the Project Specification, with server computers typically prepared for computer cabinet rack mount and client workstation as well as engineering computers typically prepared for desktop installation. All computer equipment shall be from a reputable, branded supplier.

b) Computer equipment shall carry a minimum of a 2-year warranty.

c) The computer housings shall be robust and capable of operating in either controlled environments or industrial environments, as stipulated in the Project Specification.

3.2.3 Computer monitors

a) The size and number of monitors shall be optimised to allow the operator(s) to have a detailed overview of the full plant or works at all times.

b) Server monitors shall be backlit LED LCD type at least 19 inch, 4:3 aspect ratio and a minimum 1024x768 resolution or as stipulated in the relevant Data Sheet.

c) Workstation and engineering station monitors shall be the backlit LED LCD type and at least 23 inch, 16:9 wide aspect ratio and a minimum of 1920 x 1080 resolution or as stipulated in the relevant Data Sheet.

3.2.4 Printer

a) The installation shall include at least one printer as stipulated in the Project Specification and detailed in the relevant Data Sheet.

b) The printer shall be connected to the SCADA System’s Local Area Network and accessible from all SCADA computers (server, workstation and engineering).

c) The printer shall be used for alarm and event message printing, measured value trend printing and operations and status report printing as well as any engineering change records.

d) The printer shall as a minimum be a colour laser or inkjet printer with specifications as stated in the relevant Data Sheet.

3.2.5 Uninterruptible power supply

a) All SCADA computers and peripherals shall be supplied from an Uninterruptible Power Source (UPS) which shall be an on-line synchronous (phase locked to supply frequency) single phase 230 V AC, 50 Hz, compact, self-contained UPS complete with full static bypass and all include necessary power circuitry, transformers, batteries, ventilation fan(s) and accessories.

b) The UPS shall be from a reputable supplier and shall be a standard catalogue item.

c) The UPS shall be sized for the full SCADA equipment load plus 25 % spare capacity, and shall be able to accommodate the inrush currents of all connected equipment.

d) The UPS shall be microprocessor controlled and be able to supervise critical functions and monitor circuit performance (such as temperature, battery status, mains fail, etc.). These shall be communicated to the SCADA system via a serial, galvanically isolated communications port to ensure correct management of the UPS and equipment connected to it under power fail conditions.

e) The UPS shall include visual indication of normal and abnormal operation as well as visual and audible indication of battery status.

f) The UPS shall be capable of maintaining the connected load fully operational for a minimum period of 30 minutes unless specified otherwise in the Project Specification or Technical Data Sheets. Longer back-up times shall be accommodated using additional Battery sets.

3.2.6 Networking Infrastructure

a) SCADA hardware interconnectivity and data communications network infrastructure shall provide for Level 1, 2 and 3 communications according to the standard Automation Hierarchy (i.e. Control, Supervision and Management communications respectively) and Industry standard data networks and protocols suitable for the offered control equipment (PLC, RTU, Instrumentation) shall be used, all as stipulated in the Project Specification and applicable Data Sheets.

b) The design and implementation of the networks as well as the selection of equipment shall comply with the Engineering Standard SPE-II-0003 – “Industrial Network Installation”.

3.2.7 Earthing and Surge Protection

a) All computer hardware and peripheral power supplies including all data communications links shall be protected against the harmful effects of lightning and power line surges.

b) The entire installation shall be properly earthed, all equipment enclosures and surge arrestor ground terminals shall be bonded to a common earth bar; all as specified in the Engineering Standard SPE-II-0001 “General Electronic Installations”.

3.2.8 Furniture

a) One purpose made SCADA Control Desk accommodating all of the required hardware and peripherals called for in the Project Specification and Technical Data Sheets, shall be supplied, delivered and installed as directed by the Engineer.

b) The Control Desk shall include a dust proof compartment in which the following shall be housed:

   i) Operator workstation computer (excluding, keyboard and mouse)

   ii) Dedicated UPS (unless a single, separate, floor standing UPS is called for)

   iii) Printer(s), printer paper and ink cartridges. (The compartment shall make provision to store both the used and unused printer paper.)

c) Operator screens/ monitors shall be mounted in the vertical upstand section(s) of the Control Desk at ergonomical angles. All cabling shall be done neatly in the desk recesses and no cables other than the keyboard and mouse cables shall be routed outside of the desk.

d) The Control Desk shall further contain a section where the Employer's radio voice communications equipment and security surveillance equipment can be housed (if applicable).

e) If the control desk is situated in a plant area where dust and other harmful gases may be present, the control desk shall be maintained under positive pressure by means of a pressurisation fan. An easily removable and cleanable filter shall be installed to filter air before it is released into the enclosure.

f) Sufficient storage space shall be provided in the Control Desk for the works or plant Operations and Maintenance manuals Operator Log books, Report Files as well as any other general stationary.

g) SCADA Server Computers (where applicable) shall be accommodated in dedicated rack-mount type Computer Cabinets as stipulated in the Project Specification and relevant Technical Data Sheets.

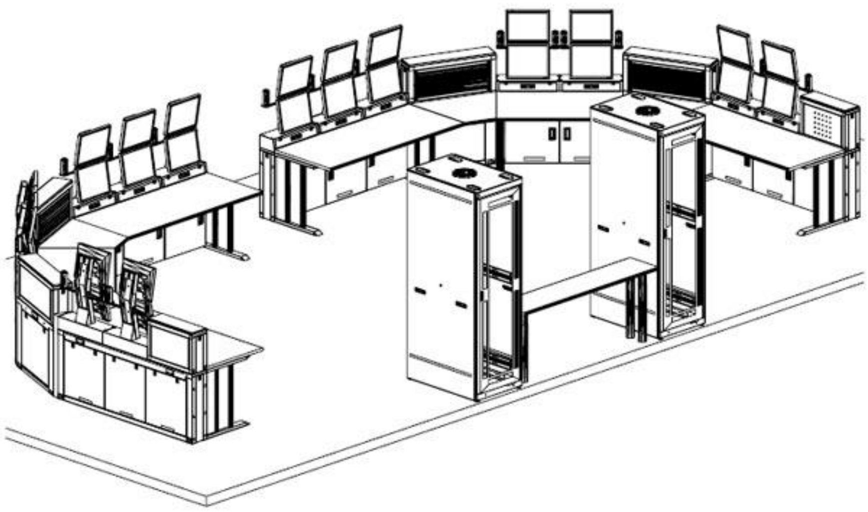


Figure 1: Typical layout of a large system Control Desks and Computer Cabinets

3.3 System Software

3.3.1 General

a) SCADA Software shall comprise of computer operating system software, hardware and peripheral drivers, SCADA specific applications (data acquisition, data storage, visualization and reporting) as well as general computer operations and maintenance software (e.g. anti-virus software, back-up software etc.).

b) Tenderers shall allow for all software in their offer and tender pricing, whether expressly specified or not.

c) Optional software available to enhance the system but not essential for the operations, and annual / versioning software revisions or additions beneficial for future extensions shall be shown and offered separately in the tender.

d) Software improvements and enhancements that occur within one year of the contract award date shall be furnished to the Employer at no additional cost.

e) All software shall have a proven industry track record with verifiable large user and technical support base.

f) All software supplied under this contract shall be registered and licensed to the Employer and the Contractor shall include proof of such licences in the Operations and Maintenance Manuals to be submitted on completion of the contract.

3.3.2 Computer Viruses

a) Unless the client has his own enterprise wide licence for Computer Anti-virus software or unless stated otherwise in the Project Specification, a copy of the latest OEM's (Original Equipment Manufacturer) anti-virus software shall be supplied and installed together with the OEM's operating system.

b) The anti-virus software package shall be of reputable manufacture with continuous update support to protect the system with the latest anti-virus technology.

c) The anti-virus software shall be provided preferably with an unlimited license linked to the Operating System License (e.g. Microsoft Security Essentials).

3.3.3 Computer Operating System

a) All SCADA computers shall be supplied with OEM versions of a suitable operating system (OS), which shall be a latest available real-time, multitasking, multithreading OS such as the Microsoft Windows OS that is compatible with the offered SCADA software unless specified otherwise in the Project Specification.

b) The operating system shall provide secure, integrated networking (LAN) features, protocols and services without the need for additional 3rd party networking software.

c) The SCADA historical and real-time database shall be accessible (read-only access) via the LAN interface for use in management information services and the Tenderer's offer shall include all database client access licences required for the offered SCADA system.

d) The operating system shall incorporate both a local and domain (work group) based security system with configurable users, groups and access permissions.

3.3.4 Special requirements

a) Under no circumstances shall it be possible to cause a system lockup, failure, or database contamination by operators entering spurious data or pressing the wrong sequence of keys or by accidentally leaning on the keyboard of the computer or any of its peripherals.

b) A "warm boot" (e.g. pressing the Ctrl, Alt and Del keys) shall be protected by means of a password.

c) Inputs by operators shall be vetted for spurious or incorrect data. Appropriate error messages shall be displayed in such cases.

d) In the case of a power failure (and subsequent run-down of the UPS) the system shall automatically shut-down saving all current status and data whereupon the system shall reboot automatically when power is restored and load the last stored status and data in order to continue normal operation. An alarm log entry shall be made stating the time and duration of the power failure.

3.3.5 Access authorisation

a) Operator access to both server and client computers shall be protected by means of the Operating System's passwords.

b) The OS security model shall provide for a hierarchy of user access by means of various user account levels, so that operators with a lower level of authority can only have access to basic operating functions, while operators with a progressively higher level of authority can have variable access including system administration and configuration functions.

c) It shall be possible to integrate the security models of server and client computers (e.g. Domain / Workgroup type security).

d) Once an operator has successfully logged onto the system with a valid password, he/she shall be able to change the password without changing the related access authorisation.

3.3.6 Real time clock synchronisation

a) The computer operating system(s) shall be capable of demanding a system date/time synchronising command from a local or network based time server and convey date/time synchronization to all connected field devices. The synchronisation shall take place automatically at least once per 24-hour period with a resolution of 1 second between all connected devices. A manual clock adjustment made on the SCADA server computer shall automatically activate the aforementioned procedure.

b) The system shall record each synchronisation into an event log including the time difference between the connected devices.

3.4 SCADA Application Software

3.4.1 General

a) The SCADA software package shall be a fully tested, supported and field-proven package suitable for Industrial automation purposes with a wide and well-established user base. Custom written software will not be permitted.

b) The software shall be supplied as a complete package for the application. No additional software or modules shall be necessary to configure or use all the features of the system. SCADA packages comprising a collection of software from various manufacturers (other than the computer operating system it is deployed on) will not be considered.

c) The SCADA software shall consist of scaleable, complementary, open architecture software objects that are user configurable to implement a complete functional SCADA in a modular fashion.

d) The SCADA software shall fully support and utilize the features of the operating system that it is deployed on (such as multi-tasking, multi-threading and security).

e) The package shall provide an extensive selection of communication protocol drivers to support various remote connected devices (PLC, RTU and Instrumentation).

f) The protocol drivers shall be robust and shall detect any communication failures to and from connected devices. Detected faults shall produce event/alarm failure signals for reporting.

g) The package shall be capable of a single user or multi-user (client / server) installation operating in a LAN configuration with the capability of having multiple workstations working simultaneously off a common database.

h) Process control logic will not be permitted in the SCADA package except where expressly specified or where written permission has been granted by the Engineer.

3.4.2 Data access methods

a) The SCADA shall support both polling and event oriented protocols for accessing data from connected field devices (PLC, RTU and Instrumentation).

b) The applicable protocol configuration(s) shall be as described in the relevant Telemetry and PLC Specifications.

3.4.3 Time and Date Stamping

a) The SCADA shall be able to accommodate and record externally time and date stamped data (data is time-stamped at the source device) as well as data that may require time and date stamping by the SCADA itself (such as operator actions and setpoint adjustments).

b) The SCADA database shall support data representation in any of the standard time formats (as selected via the Operating System Date and Time format settings) and use this for viewing, sorting and reporting of logged data.

c) All logic events, status changes and alarms shall time and date stamped in the field devices (PLC or RTU) and all SCADA commands, setpoint and parameter changes (including alarm acknowledgement) shall be time and date stamped in the SCADA.

3.4.4 Data processing

The SCADA Package shall be able to accommodate data from field devices (PLC, RTU and Instrumentation) in boolean, binary, word, integer or real number form.

3.4.5 Binary signals

a) Changes to the binary / boolean status of a signal shall be registered in the SCADA real-time memory, represented by its unique tag-name and the date & time of occurrence. This information shall be available and continuously updated for further processing, logging and report generation.

b) The system shall differentiate between two signal types, namely status signals and error/fault/alarm signals which have higher priority and automatic entry into the alarm log.

c) The system shall provide for binary signal priority processing, i.e. to exclude any signal from being logged or processed unnecessarily while maintenance is being performed to the system or a higher priority condition exists (e.g. inhibit run failure alarms on every motor when in reality a power failure has occurred).

d) Operator control commands shall be sent as binary signals. Commands shall be either momentary or latched. A latched command shall remain latched until reset by another command.

3.4.6 Integer signals

a) The system shall provide for the storage of equipment runtime hours in integer form, which shall then be used for maintenance reporting Analogue (real number) value processing.

b) Analogue/ Measured values (Instrumentation connected to a PLC or RTU or directly to the SCADA) shall be monitored and registered in the SCADA real-time memory, represented by it is a unique tag-name and its instantaneous reading. This information shall be available and continuously updated for further processing, logging and report generation.

c) The system shall allow for the following analogue processing:

   i) Limit value monitoring (only on SCADA connected to RTU. For process control, limit value monitoring shall be done in the PLC).

   ii) Strategy for substitute values - e.g. if a measuring range is exceeded (4-20 mA signal <4 or >20 mA) or if the signal transmitter or instrument is faulty, the system shall automatically generate an appropriate alarm and load a default substitute value and use it for further processing.

d) Special treatment during fault condition - by e.g. activating a fault indication and generating a fault alarm.

e) Real number outputs shall be used for assigning a limit value or setpoint to an analogue value processing in the PLC or for parameter setpoint changes in the PLC. It shall be possible to perform the following functions on the real number output:

i) Engineering conversion prior to output

ii) Setting cold start / default output values

iii) Setting output clamp limits

iv) Setting rate of change limits

f) The system shall provide for the following analogue value processing for report generation:

i) Totals (1 hour, 2 hours, 1 day, monthly, annual, etc.)

ii) Averages (1 hour, 2 hours, 24 hours, etc. averages)

iii) Extremes (minimum and maximum values for averaging periods)

iv) Integration of values, e.g. from a litres/sec value generates an integrated litres total value

v) Analogue value manipulation by means of the basic arithmetical functions e.g. summation of two inflow flow meter valves. The same functions shall be available for these derived values as for normal analogue values.

3.4.7 Counter values

Field devices shall process counter pulses and totalize values, passing them on to the SCADA system where the following processing modes shall be available:

a) Sum formation

b) Value manipulation by means of basic arithmetic functions

c) Generation of difference values (1 hour, 2 hours, etc. difference values)

3.4.8 Laboratory values

The system shall allow for entering laboratory measured values via suitably configured entry masks on the SCADA. Typical laboratory measurements will originate from portable instrumentation, manual chemical analysis and equipment run-time synchronization data after removal for maintenance.

3.4.9 Data Logging and Archiving

a) All measured values, events and alarms shall be written to a dedicated log file for long term storage on the SCADA server hard drive, database server or back-up media.

b) No data shall be automatically aged and/ or deleted from the SCADA database.

c) It shall be possible to set individual logging rates for each item of data depending on their rate of change and logging accuracy required, and archive the log files and / or database files at predetermined time intervals or on a demand basis.

d) Advanced users shall be able to easily retrieve and use archived data in any form (Plain Text, ASCII, Comma Separated Variables, Binary or Extensible Mark-up Language) using standard Microsoft products or any other third party data analysis software.

3.5 SCADA configuration for Process Visualisation and Operation

3.5.1 General

The SCADA package shall preferably provide scalable vector graphics support for the visual representation of the automated process. Operational elements of the process shall be represented by dynamic symbols in either of the standard formats such as TIFF, JPEG, BMP, WMF, PNG etc.

3.5.2 Process Mimics

a) SCADA mimic layout representing the process / plant shall be based on the works or plant Process Flow Diagrams (PFDs) as well as Piping and Instrumentation Diagrams (P&IDs).

b) Three dimensional equipment representation and plant layout as well as equipment animation shall be avoided unless it ads justifiable value to the SCADA operation AND has been approved by the Engineer.

c) The mimics shall be laid out to follow the flow of material through the plant / works.

d) The system shall allow for a hierarchy of mimics, beginning with a plant / works overview that progresses down to individual plant / works area overviews and finally individual equipment detail.

e) It shall be possible to navigate to the detail of an area or individual item of equipment by selecting it from any of the plant overview displays using either the mouse, keyboard or a touch sensitive screen / monitor.

f) All mimic displays shall be fully re-entrant meaning that the operator shall be able to proceed to any display without first having to backtrack via a previous higher level display mimic.

g) Each mimic shall have a ‘back’ button that would allow the user to return to the previous page.

h) The general mimic layout shall be subdivided into four basic sections as described below.

3.5.3 Navigation display line

A navigation section shall be provided to be used for easy navigation through the plant / works mimics and detail displays.

3.5.4 Message lines

A message line section shall be provided consisting of the three most recent operator messages. Messages shall typically consist of alarms and operator alerts.

3.5.5 Process visualisation (Mimics)

a) The process mimic section shall consist of a static background, (e.g. a tank with the associated pipe work), as well as dynamic symbols representing the related automated equipment (e.g. valves, pumps, mixers or level instrumentation associated with the tank). Measured values shall be displayed numerically and graphically. For example, the level in the tank shall be varied to emulate the real condition.

b) Equipment status, such as the operating condition of a pump, shall be displayed by variation of the graphic symbol representing the equipment, for example “green” when running and “red” when stopped.

c) Alarm values from discrete instrumentation shall be graphically displayed in a semaphore e.g. level alarms from a level switch shall be indicated on a pump sump to indicate “green” when healthy and “red” when activated.

3.5.6 Process control interface (Faceplates)

a) General

i) Each item of equipment in the plant or works that is automated, instrumented or otherwise monitored, shall be represented by an appropriate control faceplate (i.e. graphic display dialog) via which the operator can interact with that equipment.

ii) Separate faceplates shall be provided for PID loops and duty loops.

iii) Inputs by operators shall be vetted for spurious or incorrect data in which case appropriate error messages shall be displayed.

iv) In order to facilitate keyboard sequence entry it shall be possible to define macros, i.e. pressing a single key will be equivalent to a number of key entries.

v) The faceplate displays on the screen shall aid the operator in entering data from the keyboard.

vi) Additional “help” screens shall be provided, where necessary, to explain faceplate operation and key entry procedures.

b) Process operation

i) A unit for operation, for example a pump, shall be selected on the process mimic by means of the mouse and cursor. Left clicking the unit shall display its faceplate and allow entry of the required command(s).

ii) Once a faceplate has been activated, it shall show further detail about the equipment than just the mimic symbol change in colour. The faceplate shall display:

- the description and tag number of the unit
- the operating modes available for the unit (in plain text),
- the equipment status of the unit (in plain text)
- any static or variable operating parameters (e.g. controller setpoints, pump speed, current, alarm level etc.).
- a button to navigate to the trend for the equipment or control loop
- interlocks applicable to the equipment
- equipment reset buttons e.g. run hours reset

iii) The various possible operating modes shall be selectable by means of a graphic “pushbutton” or “selector switch” on the faceplate.

iv) After selection of the operating mode, the relevant symbol on the mimic shall change colour (e.g. border colours to represent modes), and the status text will change accordingly confirming the operator’s selection. Final acceptance of any instruction, data entry or selection shall always require a positive confirmation dialog.

v) Analogue and measured values, e.g. set points and limits etc. shall be entered on separate popup faceplates in a similar way. However the new numeric values shall be entered via the numeric keys of the keyboard.

3.5.7 Alarm message handling

a) The SCADA Alarm handling feature shall be configured to provide comprehensive fault and error annunciation, including acknowledgement and fault clearing procedures.

b) As soon as a fault or error occurs during normal operation, the respective area display shall start flashing, raise an audible alarm, and indicate a group alarm.

c) The operator shall be guided by the flashing area to the detailed mimic to which the fault has been localised, from where the operator shall be able to view and acknowledge the alarm and associated alarm text.

d) An audible alarm shall be provided with at least three different sounds / tones representing either high, medium or low priority alarm conditions. The alarm acknowledgement process, performed via the keyboard, shall silence the current audible alarm until a new alarm occurs.

e) Acknowledged alarm text messages that have not yet been cleared in the field, shall be displayed by means of a steady-state font colour. Only after the fault/error has been cleared/reset, shall the alarm text be removed from the list of current alarms.

f) All alarm messages configured in the SCADA shall be in clear and unambiguous text.

g) The operator shall be able to fully navigate and sort the alarm list, including acknowledged and unacknowledged alarm messages, and shall be able to filter items by type of fault or equipment type.

h) It shall be possible to define absolute value alarms for Analogue Inputs (in engineering units): HiHi, Hi ,Lo and LoLo as well as rate-of-change alarms.

i) The system shall be able to accommodate a minimum of 8 000 alarm messages at any one time. Once the limit has been reached, all acknowledged and cleared alarms shall be archived to make space for new alarms. Archiving shall also take place automatically once per day.

j) Error messages shall not take the form abbreviations, but shall consist of complete sentences or words.

k) A minimum of 8 priority levels shall be provided for alarms.

3.5.8 Trending

The SCADA configuration shall include for both live and historical colour graphical trends of all measured values (analogues) as well as select discrete states and instruments.

a) On-line (live) Trending

  i) This function shall provide the ability to show live trends of analogue or calculated values. Each stored value shall be instantaneous or average values of a number of samples, depending on the desired resolution. The trend shall therefore span a fixed time period of 1 minute to approximately 60 hours depending on the average chosen. It shall be possible to display up to 8 values (in any combination e.g. digital, analogue, etc.) per trend page.

  ii) The trend curves shall be fully configurable in terms of the line type, colour, axis scales, measurement units and numbering.

  iii) Trends curves shall be printable in full colour, on demand or via the SCADA reporting feature.

b) Historical Trending

  i) The system shall provide for historical trending curves to be displayed in the same manner as the live trends.

ii) The historical trending curves shall provide for range selection in the following standard configurations of the time axis.

- ¼ hour average - for daily historical trend curve
- 2 hour average - for weekly historical trend curve
- Daily average - for monthly historical trend curve
- Monthly average - for annual historical trend curve
- Actual value - updated every 6 seconds with the time axis full scale being selectable as 1 hour, 2 hours, 12 hours, 24 hours. The last one tenth of the display shall be updated and once it is full, the total curve shall be moved back one tenth, and so on.

iii) Trend curve shall include a navigation “slide” displaying the current values, minimum, maximum and average values over the trend range at the cursor position.

iv) The operator shall be able to freely select the beginning of the historical trend curve and he shall be able to spread the ordinate, thereby ”zooming” into or out of the trend.

v) Trend curves shall be displayable in bar graph or line graph format.

vi) Historical Trends curves shall be printable in full colour, on demand or via the SCADA reporting feature.

3.5.9 Reports

a) The system shall provide for an extensive reporting system, with output options to screen, file or printer.

b) Two broad categories of Reports shall be provided, being (1) external documentation reports and (2) operational information (instantaneous values, run hours etc.).

c) The external documentation reports shall contain the following minimum set of reports.

i) Daily detailed report and daily summary report

ii) Monthly detailed report and monthly summary report

iii) Annual report and annual summary report

iv) Fault/error/ alarm list (disturbance report)

v) Maintenance report

vi) Operator Alerts and Messages

d) The operational information reports shall include reports such as:

i) Analogue value status minimum, maximum, average and totalized values

ii) Binary value status

iii) Equipment modes and status

iv) Laboratory data

e) The operator shall be able to create custom free format reports by dragging and dropping selected information onto a report template. The printed document shall be an exact replica of the on-screen form when printed.

f) A report scheduler shall be provided enabling the operator to specify when any given report is to be generated and printed based on the time of day, day of the week or any given event.

g) Data for reports shall come from either the current live data in the SCADA memory or from historical trending log files or archived databases.

h) A separate operator message log shall be provided in the SCADA via which the plant manager and operators can capture, record and report on operational events, actions, problems and any other related messages.

3.5.10 Short Message Service (SMS) alerts

a) Unless otherwise specified in the Project Specification, the SCADA system shall include a GSM/3G modem with which the SCADA can alert the works / plant operational personnel when certain alarms or events have been triggered.

b) SMS messages shall be configured for up to 5 different recipients and message content as well as recipient contact numbers shall be freely configurable by the SCADA administrator.

3.5.11 Control System Functional Specification

a) The SCADA system shall be described in detail in a Control System Functional Specification produced by the Contractor for approval by the Engineer before configuration commences.

b) The following shall be included in this document:

i) Description of the SCADA hardware configuration

ii) Description of the SCADA software package

iii) SCADA mimic mock-ups (using any graphic tool)

iv) SCADA symbol definition (one for each type of equipment)

v) SCADA operator faceplate layout and definition (one per type of equipment, mock-up using any graphic tool)

vi) SCADA control modes

vii) Report Layouts

viii) Database design (if applicable)

ix) Trending screen layouts and grouping

x) SCADA Tag lists

xi) SCADA Alarm Lists

xii) SCADA security configuration

3.6 SCADA security

3.6.1 The SCADA system shall provide access security to prevent unauthorised access to the system and plant / works process. Securing the system through usernames and passwords shall prevent accidental reconfiguring by the process controllers and / or managers and provide a traceable log of all SCADA activity.

3.6.2 At least three levels of security shall be provided as follows, or as stipulated in the Project Specification.

a) Operators

Operators shall be required to logon to be able to perform their functions as follows:

i) View, Monitor and control the plant by navigating from mimic to mimic

ii) Stop, start and reset all equipment

iii) Change value settings

iv) View, Acknowledge and Reset alarms

v) Select, display, print and reconfigure TREND periods

vi) Print TRENDS

b) Managers

In addition to the permissions of operators, the managers must be able to perform the following functions:

i) Make controller parameter and /or control loop setting changes

ii) View the EVENTS list

iii) Reconfigure the EVENTS list

iv) Print the EVENTS list

c) Administrators/Engineering

Shall have access to all SCADA design time/ configuration menu items and functionality.

i) Operating System Task Manager

ii) Operating System Explorer

iii) Operating System User Manager

iv) SCADA Software Setup

v) SCADA communications Protocol Management.

3.6.3 The SCADA system shall be protected by a firewall, anti-virus software and access control system against unwanted external attacks.

4. INSTALLATION REQUIREMENTS

4.1 General

4.1.1 All SCADA equipment shall be installed in computer cabinets and /or in SCADA control desks (furniture) as described above.

4.1.2 The computer cabinets and control desk shall be physically located in a dedicated Control Room at the plant or works and the design and construction of the control room will be done by others unless stated otherwise in the Project Specification.

4.1.3 The control room (and server computer room where applicable) shall be air-conditioned by equipment provided under the separate contract which will also define the civil, structural (e.g. computer false floor), heating, air-conditioning, ventilation, small power and lighting requirements; unless stated otherwise in the Project Specification.

4.1.4 The installation, termination, earthing and lightning/ surge protection of the SCADA equipment shall conform to the requirements of the Engineering Specification SPE-II-0001 "General Electronic Installations".

5. TESTING AND COMMISIONING

5.1.1 The SCADA system shall be tested and commissioned as described in the Engineering Specification SPE-II-0001 “General Electronic Installations” with specific attention to the following:

a) During configuration, SCADA mimic displays, faceplates, trends and reports shall be electronically verified separately from the plant or works that it controls using a simulation environment.

b) SCADA to PLC / RTU / Instrumentation or other intelligent device communications shall be tested with the actual PLC/ RTU/ Instrument/ Device physically connected to the SCADA and the control software loaded onto that device, and with simulation of the physical I/O to those devices being monitored or controlled.

6. DOCUMENTATION AND TRAINING

6.1.1 Comprehensive documentation, training and operations & maintenance manuals shall be provided for the complete SCADA system provided under this contract for the plant or works, all as described in the Engineering Specification SPE-II-0001 “General Electronic Installations”.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

Engineering Standard

Instrumentation

25 June 2015

Revision: 0

Reference: II-0007

Leading. Vibrant. Global.

www.aurecongroup.com

Document control record

Document prepared by:
Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa

T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

A person using Aurecon documents or data accepts the risk of:
a) Using the documents or data in electronic form without requesting and checking them for accuracy against the original hard copy version.
b) Using the documents or data for any purpose not agreed to in writing by Aurecon.

Document control						aurecon
Specification title		Instrumentation				
Document ID		II-0007	**Reference number**	II-0007		
File path		N:\Admin\CPTZAENE\Business Execution\Specifications\Standards\NEW SYSTEM\FINAL\WORD				
Rev	**Date**	**Revision details/status**	**Prepared by**	**Author**	**Verifier**	**Approver**
0	25 June 2015	First issue	M Kriel	K O'Kennedy	E Biesenbach	O Fair
Current revision		**0**				

Approval			
Author signature		**Approver signature**	
Name	Kenney O'Kennedy	**Name**	Owen Fair
Title	Electrical Engineer	**Title**	Technical Director

Contents

Tables

1. SCOPE

1.1 Application

1.1.1 This Standard Specification covers requirements for the supply, manufacture, delivery, installation, calibration, testing, commissioning and maintenance of instruments for the measuring of various process variables.

1.2 General Requirements

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 instruments shall be new and unused, shall be of current manufacture, and shall be free from any defects or imperfections.

1.2.3 All equipment purchased shall have a minimum warranty of not less than 12 months. 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 and Technical Data Sheets associated with the respective material requisition documentation.

1.2.5 This Specification serves as the minimum requirements to be followed to ensure that the design of the electrical, instrumentation and control systems satisfies the following project objectives:

a) Provide a fully instrumented and automated process capable of being controlled and monitored from a remote Control Room.

b) Wherever possible implement all control in the site-wide Process Control System (PCS).

1.2.6 Instrumentation shall be provided and installed in accordance with the Process and Instrumentation Diagrams (P&ID), and the Control and Instrumentation Cable Schedule to accomplish the required process control and feedback.

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 existing equipment, plant, machinery and services.

1.3.5 The installation, including its circuit arrangements, shall satisfy the operational and functional requirements of the Employer and be readily and easily maintained throughout its operating life.

2. STANDARDS

2.1 Associated Documentation

2.1.1 This Specification identifies the Engineer'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 The design, construction, installation, inspection, testing and commissioning of all instrumentation 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 included.

2.1.4 The Contractor shall operate an approved, auditable quality assurance procedure covering the installation, inspection and testing of the various instruments.

2.2 Statutory Requirements

2.2.1 The instrumentation as incorporated on site, shall comply with the following:

a) Occupational Health and Safety Act of 1993

b) The law of the Republic of South Africa

c) Manufacturer's specifications and installation instructions

d) ICASA (Independent Communications Authority of South Africa)

2.2.2 All instruments 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

SANS Number	Description
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 60529	Degrees of protection provided by enclosures (IP Code)
SANS 60730-2-15 & -2-18	Automatic electrical controls for household and similar use
SANS 60947-5	Low-voltage switchgear and controlgear Part 5: Control circuit devices and switching elements
SANS 61000	Electromagnetic compatibility (EMC)

SANS Number	Description
SANS 61643-1	Low-voltage surge protective devices Part 1: Surge protective devices connected to low-voltage power distribution systems - Requirements and tests
Other Standards	**Description**
BS 1646	Symbolic representation for process measurement control functions and instrumentation
BS 5863	Analogue Signals for Process Control Systems
BS 6739	Code of Practice for Instrumentation in Process Control Systems: Installation Design and Practice
BS 7405	Guide to the selection of an application of flow meters
BS EN 837	Pressure gauges. Bourdon tube pressure gauges. Dimensions, metrology, requirements and testing
BS EN 1092	Flanges and bolting for pipes, valves and fittings
BS EN 12449	Copper and copper alloys. Seamless, round tubes for general purposes
BS EN 50288	Multi-element metallic cables used in analogue and digital communication and control. Generic specification
BS EN 60534	Industrial-process control valves. Dimensions. Face-to-face dimensions for rotary control valves except butterfly valves
BS EN 60770	Transmitters for use in industrial-process control systems. Methods for performance evaluation
BS EN 61010	Safety requirements for electrical equipment for measurement, control and laboratory use. Safety requirements for hand-held probe assemblies for electrical measurement and test
BS EN ISO 5167	Measurement of fluid flow by means of pressure differential devices inserted in circular cross-section conduits running full. Orifice plates, nozzles, and venturi tubes inserted in circular cross-section conduits running full
BS EN ISO 6817	Measurement of conductive liquid flow in closed conduits. Method using electromagnetic flow meters
DIN EN ISO 7027	European standard for turbidity measurement of potable water.
BS EN ISO 9906	Rotodynamic pumps. Hydraulic performance acceptance tests

3. GENERAL INSTALLATION REQUIREMENTS

3.1 Overview of Requirements

3.1.1 All instruments shall be suitable for operation on a single phase, 50 Hz alternating power supply and environmental conditions as per project description and general information.

3.1.2 The instrument enclosure shall house the instrument monitor, power supplies and the required EMI/RFI surge suppressors. A local isolator shall be provided in the instrument enclosure to isolate the instrument.

3.1.3 All instruments shall be equipped with a local indicator, indicating the process variable being measured.

3.1.4 All instruments shall be equipped to generate an isolated 4-20 mA output proportional to the process variable being measured.

3.1.5 All instruments shall be supplied complete with a suitable pedestal for mounting the instrument enclosure at 1 200 mm above finished ground level and all the required mounting brackets and material for the enclosure and all the required transducers.

3.1.6 Hand rails or kick rails shall not be used for mounting of equipment, control devices, cables or conduits. Control stations and field mounted panels shall be positioned such that there is a 600 mm wide clear access way to the panel and a 600 mm clear space around the front of the panel. The clearances are required to a height of 2 000 mm.

3.1.7 Instrumentation installed on the front of control panels shall generally be located at a suitable working height (1 400 mm above floor level). The respective electrical wiring shall not interfere with the normal operation or opening of other panel equipment.

3.1.8 Brackets, supports, bolts, nuts, washers, pedestals or any other load bearing devices shall be stainless steel and protected against corrosion related to climatic weather conditions, and/or the location of installation with respect to the process environment.

3.1.9 Pipework shall be stainless steel or HDPE with compression type couplings.

3.1.10 Wherever possible, the instruments shall be located so that they are protected from damage by passing or falling objects.

3.1.11 All outgoing and incoming signal lines (excluding transducer signal lines) shall be free floating, i.e. ungrounded at the instrument. All these signals will be centrally grounded at the main control room or field processing unit.

3.1.12 All instruments supplied shall have a proven track record in Southern Africa under similar operating conditions.

3.1.13 The equipment shall be designed and installed to operate continuously at the specified rating for 24 hours per day, 7 days per week at the operating conditions specified. Unless otherwise specified, the equipment shall have a design life of 15 years with only routine maintenance required.

3.1.14 Preference is the provision of one programmable logic controller (PLC) per process cell instead of multiple small individual PLC’s per supplied unit.

3.1.15 The installation shall be a highly reliable, safe and efficient system with fault and diagnostic reporting capabilities.

3.1.16 Minimal onsite instrument and control system installation and testing will be allowed. Contractors shall bench test and pre-calibrate instrumentation and equipment as far as possible prior to delivery.

3.1.17 Wherever possible the electrical, instrumentation and control system components shall be pre-assembled, pre-mounted and pre-wired to junction boxes prior to being transported to site. These pre-assembled components shall be completely calibrated and tested prior to shipping unless otherwise noted in the Particular Specification.

3.1.18 Standardised equipment shall be supplied as far as possible to minimise spares. Standardisation of process control deliverables, design documentation and software for the whole plant (including all equipment and packaged plant Manufacturers) is required. Standardisation shall be undertaken in such way that process efficiency and accuracy is maintained to the required levels and that actual 'whole of life cost' is considered when selecting and standardising the plant equipment design.

3.1.19 All instruments and control devices including dedicated equipment controllers supplied with the mechanical equipment shall be capable of integration with the PLC. If the package includes a controller all parameters and information needed to control and monitor the unit/process cell should be made available to the plant-wide control system. The Contractor is required and shall allow time to attend software coordination meetings.

3.1.20 The provision of all hardware and software integrated in a Manufacturer's package control system for the purpose of interfacing to the overall control system is the responsibility of the Contractor. All associated hardware and software required to complete the interface shall be documented in the Contractor's preliminary design documentation for review by the Engineer.

3.1.21 The Contractor shall provide representation to be involved in the control system design review to ensure that the selected solution and the proposed implementation methodology satisfy the requirements of the equipment supplied under the scope of supply.

3.1.22 Wherever practicable all control circuits and instruments shall be designed so as to be fail safe in the event of power, equipment or wiring failure.

3.1.23 The transmitter shall be mounted separate from the sensor and shall have local indication where specified in the Instrumentation and Control Cable Schedule.

3.1.24 The Contractor shall supply all the plant, equipment, fittings, mountings and brackets necessary to install, test and commission all instrument related products covered by this Contract.

3.1.25 The Contractor shall factory mount, pipe, tube and wire all instrumentation to the maximum extent possible. Only items that cannot be factory assembled or are subject to transport damage shall be shipped loose for field assembly.

3.1.26 Where openings through walls are provided for the Contractor to install pipe work (such as for sample water flow for the inlet pH and turbidity meters), the Contractor shall grout these openings closed after installation of the pipe work, ensuring a neat finish that matches the surrounding wall.

3.1.27 Where the diameter of the meter offered differs from the pipe diameter specified, the Contractor shall provide matching diameter pipes on either side of the flow meter, as well as suitable reducers and support brackets to enable the meter to be installed in the line. All couplings and flanges of flow meters installed in manholes/chambers shall be wrapped in Denso Tape.

3.1.28 All mountings, brackets, and pedestals shall be stainless steel.

3.1.29 Pipework shall be stainless steel or HDPE with compression type couplings.

3.2 Environmental Exposure

3.2.1 Throughout the construction period, all equipment shall be adequately protected against adverse climatic conditions and mechanical damage.

3.2.2 All instrumentation shall be designed for use in the aggressive environment encountered at a wastewater treatment works in a corrosive environment. Equipment shall be robust and simple to maintain. Equipment shall be manufactured from non-corrodible materials suitable for the application.

3.2.3 The transmitter unit of the instrumentation shall be installed indoors or in a weatherproof housing.

3.2.4 All instrument monitors shall be mounted in a weatherproof enclosure offering a protection of IP 65. The enclosure shall be padlockable and shall be equipped with a shatterproof-armour plated glass insert so that the local indicator can be read without opening the enclosure. Each glass display window shall be equipped with a shield protecting the display from direct sunlight.

3.2.5 Unless otherwise specified, the Contractor shall assume that the supplied equipment shall be installed outdoors and exposed to an environment of direct sunlight, rain, dusty atmosphere and salt laden air, and that the supplied equipment will be subjected to spillage of process liquids and splashing from high pressure wash-down water and in sections of the process plant, to corrosive liquids.

3.2.6 Non-metallic covers shall be UV stabilised long life type.

3.2.7 Sensors/detector heads shall be rated IP 68 for environmental protection and shall be able to be flooded.

3.3 Units of Measure

3.3.1 All units shall be expressed in SI (System International).

3.3.2 All piping sizes shall be expressed in nominal sizes: DN (diameter nominal) - mm.

3.3.3 Instrument tubing shall be in metric units.

3.4 Preferred Equipment List

3.4.1 A list of all proposed instrumentation and control equipment shall be provided to the Engineer for review prior to any associated procurement or construction.

3.4.2 The Contractor shall advise if there are any significant implications in terms of time, surety and value-for-money in using items other than stated in the Technical Data Sheets.

3.4.3 The Contractor shall note that the Engineer reserves the right to modify including further reduce the number of instrument and electrical equipment Manufacturers and limit models or to select a specific manufacturer / model for each equipment type to provide conformity across the Site at any stage of the project.

3.4.4 Wherever practical, the Contractor shall standardise selection and supply of instrumentation and control equipment to minimize the required number of final spares to be provided. Equipment purchased shall generally be standard items with minimal delivery periods and accessible spares availability.

3.4.5 If non-standard control equipment is approved by the Engineer, the Contractor will be responsible for the integration of this non-standard hardware in the overall control system. This is not limited to the supply of all hardware and developing the software to establish communication between the relevant PLC's.

3.5 Controller Programming

3.5.1 The Contractor is responsible for the control system software development for all controllers provided in their scope of supply.

3.5.2 Contractor control system development shall include:

a) PLC programming to control equipment and process within their scope of supply

b) The configuration of the controller to facilitate monitoring and control of the Manufacturer's package from the control system

c) Operator interfaces required to monitor and control the equipment and process.

3.6 Operator Interface Programming

3.6.1 All Human Machine Interfaces (HMI's) shall be integrated to the control system.

3.6.2 Based on the complexity of their packages control and monitoring requirements, Contractors shall provide a suitable operator interface for equipment within their scope of supply.

3.6.3 Contractors shall provide samples of their packages HMI to the Engineer for review and authorisation prior to complete system development.

3.6.4 Where the equipment included in the scope of supply includes a controller without an operator interface, the Contractor shall provide all necessary information to allow operator interface development by a third party.

3.6.5 Data logging and retrieval of equipment signals shall generally be performed by telemetry outstation/master station facilities. Where telemetry facilities are not available then solid state chart recorders with memory card logging or portable logging devices shall be used.

3.7 Equipment Numbering

3.7.1 All electrical equipment and instruments shall be identified with a unique instrument / equipment tag number according to the Particular Specification or Process and Instrumentation Diagram.

3.7.2 These tag numbers shall be used to identify the instruments / electrical equipment on the equipment itself and mounting locations.

3.7.3 Tag numbers shall carry through the entire design, appearing consistently on drawings, manuals, documents, labels, controller software, operator interfaces and data management systems.

3.8 Instrument Tags and Nameplates

3.8.1 All instruments, transmitters, control valves and pushbutton stations shall have a nameplate fitted to the instrument stand or adjacent structure.

3.8.2 Equipment shall be labelled clearly and visibly using black lettering on white background traffolyte labels fixed by at least two (2) stainless steel screws. Lettering size shall be not less 6 mm high.

3.8.3 Name plate wording shall be in accordance with the project standards.

3.9 Instrument Power Supplies

3.9.1 Instrument power supply shall be 24 V DC for all loop powered instruments.

3.9.2 Only where 24 V DC is not an option, and where approval from the Engineer has been received, shall 230 V AC be used for non-loop powered instruments. All four-wire devices and analysers, however, shall be powered using 230 V AC.

3.9.3 Loop powered instruments shall be powered from control system panels.

3.9.4 Non-loop powered instruments shall have individual miniature circuit breakers for protection, in Control panels or field stations.

3.10 Process Isolation

3.10.1 Isolation valves shall be provided so that valves and instruments can be removed for maintenance without draining tanks or reservoirs and without depressurising entire systems.

3.10.2 The first isolation valve for instrument connections shall be a full process rated piping valve (not an instrument valve).

3.10.3 Separate process connections are required for each instrument, including pressure gauges.

3.10.4 Process connections for instruments on vessels shall be dedicated to the instrument (Instrument bridles are not permitted) and not shared with process piping.

3.11 Junction Boxes

3.11.1 All signal wiring, and power wiring that enters or leaves a skid or a package system shall be terminated in frame mounted junction boxes.

3.11.2 Separate junction boxes shall be provided for instrument signals, non-instrument signals and power supply cables.

3.11.3 Analogue and digital signal cabling may be installed within common junction boxes.

3.11.4 Similar signal types shall be grouped to avoid electrical interference between signals and to allow the Contractor to easily connect cables to the terminals.

3.12 Moving and Shipment

3.12.1 Removal of instrumentation shall be avoided wherever possible by provision of adequate tube, cable, instrument supports, brackets and structure and installation of additional temporary structure for transport. The Contractor’s installation shall also facilitate disconnection and reconnection by convenient location of junction boxes, and piping / tubing breaks.

3.12.2 Some instrumentation may still however require partial disassembly for protection against vibration, environment, (sea) transport and handling damage.

3.12.3 All equipment, panels and cables shall be fully sealed for transport.

3.12.4 A full set of erection, reassembly and testing instructions shall accompany the equipment.

3.12.5 Instrument installation shall be consistent with the project standard instrument installation details issued by the manufacturer.

3.12.6 Loose instruments shall be separately packed in shipping crates that are dust-tight, moisture-resistant, and substantial enough to withstand ocean shipment and warehouse handling, and to prevent damage to equipment.

3.12.7 Instruments shall be tagged to match the instrument number to the project standard.

3.12.8 All electrical, electronic and electro-mechanical equipment shall be protected against ingress of moisture during shipping.

3.12.9 Packing shall allow for thermal expansion and contraction during transport and storage.

4. LIGHTNING AND SURGE SUPPRESSION

4.1 General

4.1.1 All instruments shall be protected against lightning and other EMI/RFI in the following way:

a) The power supply to the instrument shall be protected at the instrument by means of line surge voltage protection unit.

b) The instruments shall be protected against surges on all outgoing and incoming signal lines.

c) Loop isolators or surge suppressors of the instrumentation cabling shall also be provided at the PLC.

4.1.2 In addition to the above, all outgoing and incoming signal lines shall be protected by means of a plug-in fuse with light indicator.

4.1.3 Surge protection devices shall be provided at both ends of the 4-20 mA signal cables and digital data lines that clamp the voltage to no more than 45 volts. Each device shall be securely bonded to the earthing system. The case of each transmitter and each receiver shall be connected to the earthing system.

4.1.4 Remote transmitters shall use a local earth system.

4.1.5 Surge protection devices are not required if the signal loop:

a) Does not extend outside of the switchboard or

b) Does not extend outside the confines of a building

4.1.6 Surge protection devices shall be of the series connected type, comprising of three stages of protection, failsafe operation (fail to short circuit), common and differential mode protection.

4.1.7 Metal instrument cases and panel sections shall be earthed, where possible, by metal to metal contact through their supports. Where this is not possible, a green/yellow PVC insulated 2.5 mm^2 copper wire shall be used to connect the case to the nearest electrical earth bar.

5. FIELD SENSORS

5.1 General requirements

5.1.1 Process sensors (i.e. ph electrodes, electronic dip devices, chlorine sensors etc.) shall be located as close to their relevant transmitters as reasonably practicable. The sensor signal cable shall where possible avoid areas of extraneous interference (e.g. EMI, RFI). Strict observance shall be made to cable segregation and installation requirements.

5.1.2 Where sensors are required to be installed in pumped sample lines, the length of sample pipe work from the process main to the sensor shall be kept to a minimum. Pumped sample flow rates shall have a minimum velocity of 1.0 m/s and a maximum velocity of 1.5 m/s, and appropriate filtering shall be installed to protect the sensor from mechanical damage and electrode poisoning.

5.1.3 The sensor location shall generally be installed in a turbulent free environment following the Manufacturer's recommendations for the number of diameters of straight pipe lengths upstream and downstream of any restrictions.

5.1.4 The sensor shall not be installed in areas where excessive temperatures are anticipated. Where additional by-pass pipe work is required then adequate valve arrangements shall be installed to ensure effective isolation of the sensor.

5.1.5 Transmitted analogue outputs for recording, monitoring and control shall generally be 4-20 mA.

5.1.6 Where the installation is located in PVC pipe work and is adjacent to potential sources of EMI, then adequate earthing arrangements shall apply local to the magnetic flow meters (i.e. ground earth rods).

5.1.7 The installation of 'wet' sensors and process pipe work into electrical control panels is strictly forbidden.

6. FLOW AND LEVEL

6.1 General requirements

6.1.1 Any type of flow meter that is technically suited for the application may be considered for flow measurement.

6.1.2 All flow measurements expresses as ratios or that are cascaded with other process variable shall be linearised.

6.1.3 All flow meter runs shall have connections for static pressure and fluid temperature measurement. These connections shall be located at least 8 pipe diameters downstream of the primary measuring device.

6.1.4 Flow element shall be sized so that:

a) Normal flow rate falls at approximately 70 % of maximum scale range

b) Minimum flow is not less than 30 % of maximum scale range

6.1.5 The calculations for flow elements shall be done at the following standard reference conditions:

a) Flow liquids - 101,325 kPA abs @ 20 ºC

b) For gas and vapours - 101,325 kPA abs @ 0 ºC

6.2 Orifice plate flow installations

6.2.1 The upstream and downstream lengths of the orifice meter tubes for all applications shall be according to ISO 5167.

6.2.2 Prefabricated meter tubes shall be mandatory only if a 2 % or better accuracy in measurement is required by the process and when it is not possible to obtain this accuracy using field fabricated meter tubes made from available materials at local facilities.

6.2.3 The length of prefabricated meter tubes shall as a minimum be 15 D upstream and 7 D downstream from the orifice flange face. (Where D = pipe diameter).

6.2.4 Orifice plates shall be installed between weld neck orifice flanges, of which the material shall be according to line class.

6.3 Electromagnetic Flow Meters

6.3.1 General

The instrument shall be of a type suitable for application in raw sewage and activated sludge. It shall have high stability properties and shall require negligible maintenance over extended periods.

The flow meters shall comprise:

a) Detector head

Locally mounted control unit/transmitter, with display of current and accumulative flow (in litres per second and kilolitres respectively). The control unit shall generate a 4 – 20 mA signal proportional to the flow reading, suitable for transmission to a remote PLC (up to 1 000 m away). If mounted outdoors, the control unit shall be mounted in a weatherproof box, with a shield protecting the glass display window from direct sunlight.

b) All power supply and signal cabling

c) All mountings, brackets, pedestals etc., required to install the equipment

6.3.2 Operating principle and construction requirements inauguration

a) The electromagnetic flow detector shall consist of a length of smooth bore pipe having an equal internal diameter to that of the pipeline into which it is to be installed. This pipe insert shall be non-magnetic and lined throughout its bore with an electric insulant. A magnetic field shall be generated across this pipe insert and the two diametrically opposing electrodes shall detect the voltage generated when liquid flows through the field. This generated voltage shall be amplified by a remotely mounted amplifier and converted to an electric signal suitable for receiving instruments such as indicators, recorders, integrators and controllers.

b) All electromagnetic flow meters shall consist of a separate detector head and amplifier.

c) The detector head shall be of a robust construction and shall suffer no harmful effects if submerged, i.e. protection of enclosure to be IP68.

d) The detector liner shall be of hard wearing ebonite rubber suitable for sewage water applications and shall extend over the flange faces.

e) The detector head electrodes and earthing discs (to be supplied with the instrument) shall be made of stainless steel grade 316 or better.

f) The electrodes shall be automatically cleaned. Any build-up of fats and other debris on the electrodes shall not influence the operation of the instrument. In the selection of the instrument due cognisance shall be taken of the potential fatty nature of sewage water.

g) The amplifier shall be mounted in the previously described instrument enclosure, together with the previously specified auxiliaries such as surge suppressors, etc.

h) The amplifier shall be equipped with a digital current rate of flow indicator (in litres per second), preferably of the LCD type, a non-resettable flow totaliser (in kilolitres or cubic metres), a galvanically isolated 4-20 mA output linear to flow and an isolated pulsed output for remote flow totalising.

i) The instrument shall have a variable span facility with automatic zero control and a signal hold facility.

j) The instrument shall preferably operate on a pulsed DC field or other means to reduce power consumed and prevent electrode polarisation and zero drift.

k) The magnetic flow meter shall be capable of withstanding the test pressure experienced during mains testing without impairing operating performance.

6.3.3 Installation requirements

a) The control unit shall be mounted in a weatherproof box, with a shield protecting the glass display window from direct sunlight. The instrument enclosure shall be pedestal mounted adjacent to the flow chamber 1 200 mm above natural ground level.

b) A removable pipe section of adequate length will be provided by the piping Contractor. This pipe section will be flanged on one side and will be supplied with a coupling on the other side. The Contractor will be required to shorten the pipe insert to accommodate this flow meter head. Before ordering the detector head, the Contractor shall ascertain the flange details of the pipe supplied so that the detector flanges and pipework flanges match.

c) Where the flow in the pipe is too low for the flow meter to register, a flow meter with smaller diameter shall be considered and approval obtained from the Engineer.

d) Where the diameter of the flow meter is not exactly the same as the internal diameter of the pipe in which it is to be installed, the Contractor shall provide suitable length matching diameter pipes on either side of the flow meter, as well as suitable reducers (with maximum angle of 8º) and stainless steel support brackets. All couplings and flanges shall be wrapped in Denso Tape.

e) The lining of the flow meter head shall not be used as a gasket. Suitable gaskets shall be provided and installed between the flow meter head, earthing rings and adjacent pipe work.

f) A suitable local earth shall be provided by means of 1,8 m copper earthing electrodes. Sufficient electrodes shall be provided to obtain an earth resistance of less than 1 ohm.

g) Where magnetic flow meters are installed then dual earth rings with earthing straps shall be installed at either end of the meter flange face. The earthing straps shall be attached to the process pipe work and shall provide earthing continuity.

h) The instrument installation shall include all interconnections and sundry requirements between sensor and control/amplifier unit.

i) Magnetic flow meters shall be rated for continuous submergence to 5 m depth, and shall be suitable for installation buried underground.

j) Magnetic type flow meters installed in manholes/chambers shall be rated with Type IP68 Environmental Protection, and shall be suitable for installation buried underground.

k) When the magnetic flow meter is installed in manholes/chambers, the Contractor shall provide details to the Civil Contractor on how the manholes and chambers should be constructed. In each chamber two reducers should be installed one flanged the other plain ended, normally done by the Civil Contractor, which should be based on the flow meter supplied. The reducers shall be fabricated with an 8º angle, and will be temporarily joined by the Civil Contractor with a spool-piece.

l) The Contractor shall be responsible for dealing with any water in the pipelines in order to install the flow meters (the pipelines may be in use before the flow meter installation takes place), and for removing the respective temporary spool-piece and delivering it to the Employer’s store.

m) Included with the flow meter, the Contractor shall provide the necessary pipework, fittings and supports to fit the flow meter to the reducers such that flexibility for removal of the flow meter is allowed and that the required accuracy of measurement is achieved.”

n) The flow meter chamber shall drain by gravity to the nearest storm water manhole or catchment area with pipe of minimum 50 mm diameter.

6.3.4 Accuracy

The accuracy of the instrument shall be guaranteed to be equal or better than:

a) ± 0,5 % of measured flow in the flow range 50 – 100 %

b) ± 0,1 % of full scale for flows in all other ranges

The repeatability of the instrument shall be better than 0,1 % of full scale deflection and the linearity of the instrument shall be better than 0,05 % of full scale deflection.

6.3.5 Maintenance

The instrument shall be maintenance free.

6.4 Ultrasonic Open Channel Flow Meters and Level Meters

6.4.1 General

a) All ultrasonic open channel flow meter shall be microprocessor based, non-contact level meters and be able to be programmed to read flow accurately passing through any type of flume or over any type of weir, or to read level/volume accurately in an irregularly shaped container.

b) When measuring flow through a flume, the measured flow shall be based on the level in the approach section to the flume.

c) Before calibrating the flow/level/volume rates, the Contractor is to take accurate measurements with the help of a laser (accurate to 1 mm) of the relevant civil structure used for installation. The exact structure size must be used for programming the controller, especially when new instruments are installed on existing flumes/weirs.

6.4.2 Operating principle

A burst of ultrasonic pulses are transmitted from a transducer head, which is not in contact with the medium. These pulses are reflected of the top surface of the medium and received by the same transducer. The time delay between the transmitted and received signal is proportional to the level between the transmitter/receiver, which is fixed, and the medium, which is variable, since the level can be calculated. To compensate for the temperature dependence of the ultrasonic signal, the air temperature shall be measured at the transducer and shall be taken into consideration when the level difference is calculated between transmitter and medium.

6.4.3 Constructional requirements

a) The ultrasonic transducer shall include a built-in temperature sensor and shall have a minimum enclosure rating of IP 65. The transducer shall be corrosion protected as well as immune against UV radiation.

b) The level calculation shall be temperature compensated.

c) For flow application, the instrument shall provide for the following standard primary flow elements:

   i) Venturi flumes

   ii) V-notched weirs

   iii) Parshall flumes

   iv) Broad crested weirs

d) Any special obstruction with a known relationship between height of medium and flow rate. (For this purpose a ten point lock-up table with linear interpolation is deemed satisfactory)

e) For flow applications, the instrument shall be equipped with a local flow rate indicator and an 8 digit controller. If the controller is fed from the microprocessor, it shall be supplied with a minimum of 24 hour battery backup to prevent data loss in the event of power failure.

f) In addition to the above, for flow meter applications, a galvanically isolated pulsed output shall be provided to the remote controller.

g) A galvanically isolated 4-20 mA output, linear to flow or level shall be provided for remote indication and processing.

h) Where no stilling well is provided as part of the measuring structure, a suitably dimensioned stilling well shall be supplied as part of the instrument.

i) The control unit shall be supplied complete with battery backup to prevent against loss of set-up data in the event of a power failure.

6.4.4 Installation requirements

a) The ultrasonic transducer shall be supplied complete with mounting bracket and frame. The mounting frame shall be rigid and made from stainless steel. The transducer shall be mounted in such a way that it is free from all handrails, walkways, etc. Passing traffic and the operation of other machines in the vicinity of the transducer shall have no influence on the transducer.

b) Where required in the opinion of the Engineer, a suitably dimensioned stilling well shall be supplied and installed.

c) The Contractor shall conform to the manufacturer's recommended instructions for the positioning and mounting requirements for the installation of the insertion flow meter.

d) The installation shall include for all required interconnections and sundries between the sensor and control unit.

6.4.5 Accuracy

The accuracy of the level measurement shall be better than 0,25 % of full scale.

6.5 Averaging Pitot Tube Gas Flow Meters

6.5.1 General

The instrument shall be suitable for measuring flow in sewage/sludge digester gas. The digester gas consists mainly of methane gas (CH4), moisture, sulphurous and other impurities. The primary flow element shall impose a minimum permanent pressure loss.

6.5.2 Operating principle

The flow sensor shall measure the average dynamic plus static pressure (average high pressure) and the average static pressure (average low pressure) in the flow stream. The difference between the average high and low pressures gives the dynamic pressure with which, in accordance with the Bernoullis theorem, the flow rate can be calculated.

6.5.3 Construction

a) The flow sensor shall span the total pipe diameter.

b) The flow sensor shall be symmetrical to facilitate bi-directional flow measurement.

c) The required number of parts shall be calculated in accordance with the pipe diameter to achieve maximum stability and accuracy.

d) The port locations shall be determined as per Chebyshev calculus for correct averaging.

e) The flow sensor shall be shaped to establish a fixed separation point of the medium on the sensor to eliminate any shift in the low pressure signal that can cause a loss of accuracy. The design of the sensor shall be such that it's accuracy is not influenced by fouling the sensor surface through impurities in the gas. Round sensors are therefore unacceptable.

f) The flow sensor shall be constructed out of high grade stainless steel.

g) The flow sensor shall be designed and installed that it can be installed, removed and reinstalled without system shutdown.

h) The instrument shall be supplied complete with differential pressure transmitter and a control unit giving a linear local rate of flow indicator and a flow totaliser.

i) The instrument shall generate a galvanically isolated linear to flow 4-20 mA output for remote indication and calculation.

j) A galvanically isolated pulsed output shall be generated by the instrument for remote totalisation.

k) The control unit, power supplies, indicators and signal generators shall be mounted in the previously detailed instrument enclosure.

6.5.4 Installation

a) Where the instrument is to be installed in a non-metallic pipe, the scope of supply shall include the replacement of a suitable length of pipe in stainless steel or copon coated mild steel with the necessary fittings attached to the pipe.

b) Where the installation is to be made on a metallic pipe, the scope of supply shall include for the provision and installation of all required fittings on the main pipe.

c) In all cases, the instrument shall be supplied and installed complete with all isolating valves, insert and restart mechanisms, instrument connections, instrument pipe work and instrument valves to give a complete working and serviceable installation.

6.5.5 Accuracy

An accuracy of better or equal to ± 1 % shall be maintained over a flow turn down of greater than 10 to 1, independent of the Renolds number. The repeatability of the instrument shall be equal or better than ± 0,1 %.

6.5.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

6.6 Flow Switches

6.6.1 Flow switches shall be of the calorific (thermal) type.

7. PRESSURE

7.1 General requirements

7.1.1 Pressure element materials

The wetted parts of process pressure measuring instruments shall be made of 316 stainless steel unless dictated otherwise by the nature of the process. Alternative materials are acceptable on instrument measuring pneumatic lines.

7.1.2 Suppressed range or elevated range instruments

a) Suppressed range or elevated range pressure measurement instruments shall be furnished where necessary to provide additional measuring sensitivity for control purposes.

b) Each installation with an instrument having an elevated or a suppressed zero shall have a pressure gauge that can indicate actual pressure during start-up and shutdown.

7.1.3 The pressure instrumentation shall be able to withstand a continuous over pressure of 200 % of maximum process static pressure.

7.1.4 Pressure Transmitter

a) Instrument shall be indicating, electronic type based on capacitance principle.

b) The instrument shall be “smart unit” that would allow calibration and diagnostic checking by hand held calibrator.

c) Instrument shall have local display of pressure.

7.1.5 Differential Pressure Transmitter

a) Transmitter shall be indicating, electronic type based on capacitance principle.

b) The transmitter shall be “smart unit” that would allow calibration and diagnostic checking by hand held calibrator.

c) Instrument shall have local display of differential pressure.

7.1.6 Mechanical Pressure Gauges

a) Analogue mechanical or bourdon tube pressure gauges shall be of the bottom entry type and shall have a face of at least 60 mm in diameter with clear, readable markings and indicators. Details in this regard shall be supplied by the Contractor in the operation and maintenance manuals.

b) The indicated range on the gauge shall span 120 % of the operational pressure range specified for the relevant equipment. Accuracy shall be within 3 % of the full scale deflection value. An adjustable indicator shall be set to indicate the maximum operational system pressure clearly.

c) It shall be possible to isolate the pressure gauge from the pipe pressure by means of a valve or a gauge cock, which shall be supplied and installed by the Contractor and shall be included in the tendered rate for the equipment.

d) A gauge protector shall be fitted where a gauge has to indicate pressures in corrosive media or liquids that could easily clog the pressure ports. It is a requirement that gauge protectors be fitted where sludge is the working medium.

e) Pressure gauges fitted to hydraulic pipe lines shall be glycerine-filled for damping purposes, and gauges fitted to pneumatic or gas pipelines shall be vacuum damped.

7.1.7 Pressure Switch

Pressure switches shall be of the Diaphragm type.

8. ANALYTICAL INSTRUMENTS

8.1 Dissolved Oxygen Meters

8.1.1 General

The instruments shall be of a type specially developed for application in wastewater and actuated sludge. It shall have high stability properties and shall require negligible maintenance over extended periods.

8.1.2 Operating principle

a) The sensor shall be coated with a luminescent material. Blue light from an LED is transmitted to the sensor surface. The blue light excites the luminescent material. As the material relaxes, it emits red light. The time from when the blue light was sent and the red light is emitted is measured. The more oxygen that is present the shorter the time it takes for the red light to be emitted. This time is measured and correlated to the oxygen concentration. Between the flashes of blue light, a red LED is flashed on the sensor and used as an internal reference.

b) Dissolved oxygen sensors, which are based on the galvanic cell system utilising a membrane to separate the electrolyte and electrodes from the medium, will not be acceptable.

8.1.3 Construction

a) A probe utilising anodes and cathodes shall not be used. Probes shall not make use of a continuously cleansing system, which makes use of a rotating, spring loaded and isolated grindstone.

b) Rather probe making use of luminescent material shall be used.

c) A polystyrene coating on the sensor shall protect the sensor from sunlight.

d) The probe shall be suitable for measurements of dissolved oxygen in an aeration basin, where the linear velocity of the medium may vary between 0 and >1 m/s.

e) The construction of the probe shall be such that there is a continuous circulation of the medium past the electrodes. More than 98 % of the volume of medium surrounding the electrodes shall be displaced in less than 2 minutes.

f) The dissolved oxygen shall be suitable to measure the dissolved oxygen level up to 5 m below the surface of the medium.

8.1.4 Installation requirements

a) The probe shall be factory calibrated before being installed.

b) All equipment mounted outside the instrument enclosure shall be fully weatherproof and suitable for mounting in direct contact with raw sewage and actuated sludge.

c) The dissolved oxygen probe shall be supplied complete with a swivel mounting bracket to position the probe in any position between 0 and 3 m from the mounting wall and to adjust the level of the probe between 0,5 and 5 m below the surface of the medium. The mounting bracket shall be strong enough to accommodate the movement of the medium caused by surface mounted aerators and mixers.

d) A suitable plug in arrangement shall be provided for the probe leads to facilitate removal of the probe for maintenance purposes.

e) Sufficiently long probe leads shall be supplied with the instrument to facilitate the desired installation.

f) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.1.5 Accuracy

The accuracy of the instrument shall be guaranteed equal or better than 0,2 ppm in the range 0-5 ppm and 0,3 ppm in the range 5 - 15 ppm in the actual installation positions.

8.1.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.2 pH Meters

8.2.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall be of the in-line type and require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe

b) Locally mounted control unit/transmitter, with display of current and accumulative flow (in litres per second and kilolitres respectively). The control unit shall generate a 4 – 20 mA signal proportional to the flow reading, suitable for transmission to the remote PLC.

c) A weather proof box with a shield protecting the glass display window from direct sunlight.

d) All mountings, brackets, pedestals etc., required to install the equipment, taking account of the turbulent mixing conditions prevailing at the proposed measuring points

8.2.2 Construction

The transmitter enclosure shall be rated at IP 65.

8.2.3 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

e) All equipment and standards/solutions for calibration of the meters, stored in a sturdy and portable container shall be provided after installation.

8.2.4 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.3 Tubidity Meters

8.3.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with local display of turbidity. The control unit shall generate a 4 - 20 mA signal proportional to the turbidity, suitable for transmission to the remote PLC.

c) Self-priming feed water supply pump with all pipework and isolation valves, to draw sample water from the sampling point, transfer it to the measuring unit and back to the main flow.

d) A self-cleaning system.

e) A weather proof box, in which the measuring and control units are to be installed.

8.3.2 Operating principle

a) Water shall be taken from the main pipe line through a self-priming feed water supply pump, to draw sample water from the sampling point. Water shall be transferred to the measuring unit and back to the main flow system, preferably the filter outlet chamber.

b) The measurement technology shall use infrared pulse scattered light process according DIN EN ISO 7027.

c) The sensor shall continuously measure turbidity in water using detectors at 90 and 180 degrees.

d) The verification of calibration for the sensor shall be by StablCal or dry standard CVM module.

8.3.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.3.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.3.5 Accuracy

a) The turbidity meters shall be suitable for measuring the turbidity (in NTU) over a range of 0.0001 to 1000 NTU.

b) The precision shall be ± 0.5 % or ± 0.008 NTU of the measured value.

c) The response time shall be approximately 1 to 60 seconds.

d) The flow rate of sample shall be 0.2 to 1 L/minute.

8.3.6 Maintenance

a) The sensor shall be equipped with a self-cleaning sample chamber that uses a silicon wiper that is held in place magnetically.

b) Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.4 Mass Flow Meters

8.4.1 General

a) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

b) The meters shall be coriolis type units, suitable for measuring the mass of the specified parameter in the chemical solution over the specified flow range and shall include for density calibration.

The mass flow meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display of current and accumulative flow (in milligrams per litre and kilolitres respectively). The control unit shall generate three 4 - 20 mA signals proportional to the chemical solution mass flow, density and temperature respectively, each suitable for transmission to a remote PLC (up to 300 m away)".

c) A weather proof box with a shield protecting the glass display window from direct sunlight.

8.4.2 Construction

The transmitter enclosure shall be rated at IP 65.

8.4.3 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed and shall be supplied with official calibration Test Certificates.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

e) Where the diameter of the mass flow meter is not exactly the same as the internal diameter of the pipe in which it is to be installed, the Contractor shall provide suitable length matching diameter pipes on either side of the flow meter, as well as suitable reducers and support brackets.

8.4.4 Accuracy

The precision shall be ± 3 % of the measured mass.

8.4.5 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.5 Residual Chlorine Meters

8.5.1 General

The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display of current free chlorine concentration. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

c) Self-priming feed water supply pump with all pipework and isolation valves, to draw sample water from the sampling point, transfer it to the measuring unit and back to the main flow.

d) A weather proof box, in which the measuring and control units are to be installed.

8.5.2 Operating principle

Water shall be taken from the main pipe line through a self-priming feed water supply pump, to draw sample water from the sampling point. Water shall be transferred to the measuring unit and back to the main flow system.

8.5.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.5.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.5.5 Accuracy

The residual chlorine meters shall be suitable for measuring the concentration of free chlorine (in milligrams per litre) over the range of 0.01 to 20 mg/l, to within 3 % of the actual value, in water with a pH of greater than 8.5.

8.5.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.6 Chlorine Leak Detector

8.6.1 General

a) A local display shall indicate the level of chlorine concentration in the area.

b) Audible and visual alarm facilities shall be available at the detector, and the alarm signal must be able to be transmitted to a remote station, if required.

c) The instrument shall be equipped with a test facility to test the alarm operation.

d) The sensor shall be field serviceable.

e) The chlorine detector shall be suitable for the detection of chlorine gas in the atmosphere.

f) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

g) Measuring unit/detector head/probe.

h) Control unit/transmitter, with display of current free chlorine concentration. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

i) A weather proof box, in which the measuring and control units are to be installed.

j) Audible and visual alarm facilities shall be available at the detector, and the alarm signal must be able to be transmitted to a remote station, if required.

k) The instrument shall be equipped with an integral gas generator to automatically test the sensor each day. An alarm shall be sounded should the sensor fail.

l) The design shall be modular to allow single and multi-point detection.

m) The detector shall be supplied with battery back-up for at least 4 hours.

n) A local display shall indicate the level of chlorine concentration in the area.

8.6.2 Operating principle

The sensor shall be sensitive to chlorine gas at levels lower than the OHSACT specify. This level shall typically be in the region of 1 ppm or 3 mg/m^3.

8.6.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.6.4 Installation requirements

a) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

b) The sensor shall be factory calibrated before being installed.

c) Sufficiently long sensor leads / wiring shall be supplied with the instrument to facilitate the desired installation.

d) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.6.5 Accuracy

The chlorine leak detector shall be suitable for measuring the chlorine in the atmosphere to within 3 % of the actual value.

8.6.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.7 Streaming Current Detector

8.7.1 General

a) A local display shall indicate the ion charge.

b) The sensor shall be field serviceable.

c) The instruments shall be of a type specially developed for application in water treatment plants. It shall have high stability properties and shall require negligible maintenance over extended periods.

The meters shall comprise:

a) Measuring unit/detector head/probe.

b) Control unit/transmitter, with display. The control unit shall generate a 4 - 20 mA signal proportional to the concentration, suitable for transmission to the remote PLC.

c) An electronically controlled drive mechanism

d) A weather proof box, in which the measuring and control units are to be installed.

8.7.2 Operating principle

The SCD analyser detects the electro kinetic charge of a solution to monitor suspended solids and control the addition of flocculants.

8.7.3 Construction

The transmitter enclosure shall be rated at IP 65.

8.7.4 Installation requirements

a) The sample, sourced sufficiently far away from the point at which dosing takes place to permit good mixing, shall preferably be gravity fed to, and drained from, the sample chamber. Where this is not possible, a pump may be used.

b) All mountings, brackets, pedestals, etc. required to mount the equipment and all pipework required to achieve a fully working installation shall be stainless steel.

c) The sensor shall be factory calibrated before being installed.

d) Sufficiently long probe leads / wiring shall be supplied with the instrument to facilitate the desired installation.

e) The instrument installation shall include all required interconnections and sundries between the probe and control unit.

8.7.5 Accuracy

The chlorine leak detector shall be suitable for measuring ion charge within 3 % of the actual value.

8.7.6 Maintenance

Other than the cleaning of the sensor over extended periods (intervals greater than 12 months), no other maintenance should be required.

8.8 General

8.8.1 The sample, sourced sufficiently far away from the point at which dosing takes place to permit good mixing, shall preferably be gravity fed to, and drained from, the sample chamber. Where this is not possible, a pump may be used.

9. ANALYSER STATIONS

9.1 General

9.1.1 Where specified, analyser instrumentation shall be grouped together into an analyser station. An analyser station shall consist of the following:

9.1.2 Piping

a) All piping must be 12 mm 316 stainless steel tubing.

b) The tubing shall be secured against the backing plate by means of saddles where applicable.

c) All fittings shall be 316 stainless steel.

d) Bends shall be kept to a minimum.

e) All tubing runs shall be vertical or horizontal

9.1.3 Sample Pot

a) The sample pot shall be 316 stainless steel. The pot shall be of dimensions 150 mm high by 150 mm wide and 150 mm deep.

b) The sample pot shall be installed in such a manner as to allow a beaker to be inserted to take manual samples.

c) The outlet of this sample pot will run to the drain.

d) Water for the sample will be obtained from the outlet of the header pot and will be controlled by means of an isolation valve, ½ inch.

9.1.4 Inlet Manifold

a) The inlet manifold shall be 316 stainless steel.

b) The outlet of the header pot shall be connected to the inlet manifold from the right hand side.

c) The inlet manifold shall have a drain valve at the bottom and piped to the outlet drain.

d) The top of the inlet manifold shall have a ball valve and needle valves for each instrument which will provide a means of isolation and control respectively for the instruments.

9.1.5 Outlet Drain

a) The outlet manifold shall be constructed from 316 stainless steel.

b) The outlets of each analyser will be connected to the outlet manifold with each analyser outlet feeding into a funnel into the outlet manifold.

9.1.6 Analyser Station and Mounting Frame and Backing

a) The analyser shall have 316 stainless steel frame. This frame shall support a 316 stainless steel backing plate.

b) The backing plate shall have a minimum thickness of 2 mm.

c) All the instruments, junction boxes, trunking, supports, brackets etc. shall be mounted on the backing plate.

d) The backing plate shall be drilled and tapped and no nuts are to be used on the back of the backing plate.

e) The entire installation shall be neat and easily accessible to maintenance staff.

f) A 316 stainless steel shelf shall be installed to enable maintenance staff to carry out calibration of instruments. The shelf shall be firmly supported and form part of the installation.

9.1.7 Analyser Enclosure

a) The analyser enclosure shall be rated IP95.

b) The enclosure shall have a minimum thickness of 2 mm.

c) Square key flush mounting locks and 316 stainless steel hinges shall be used.

d) Cable entry shall be from the bottom.

e) All wiring shall be done through grey slotted trunking of adequate size with room for additional wiring if required.

f) 5 Amp circuit breakers shall be provided for the supply to each instrument, for the feed supply pump and for each flow switch.

g) A door interlocked lockable isolator shall be provided.

h) Fused terminals complete with fuses shall be used to isolate the 24 V DC supply to the status contacts of the flow switches.

i) Three 2 position key switches shall be mounted on the door. These shall bear the labels “Maintenance” and “Online” on the front door of the cabinet.

j) When the switch is in the maintenance position (left position) a digital signal shall be sent to the PLC and on the SCADA shall be indicated that the instrument is in “maintenance”.

k) A fused terminal will isolate the power to the key switches mounted on the door.

9.1.8 Flow Switches

a) The outlet of each instrument and the overflow from the header pot shall be provided with a flow switch.

b) The flow switches shall be 24 V DC and have 1 potential free changeover contact.

c) Each flow switch shall be housed in its own junction box inside the analyser station.

d) The junction box shall contain a DIN rail with terminal blocks to terminate a four pair cable plus earth. The first pair will carry the 24 V DC supply to the flow switch.

e) Terminal blocks shall have end stops on both ends.

10. WEIGHING INSTRUMENTS

10.1 Load Cells

10.1.1 The following is applicable to the installation of Load Cells:

a) Load cells shall make use of the strain-gauge principle unless otherwise specified.

b) The mechanical design of the installation shall be designed to minimize horizontal forces.

c) Load cells shall be connected in parallel and correctly shimmed to ensure equal load distribution.

d) A Three cell configurations shall be preferred if practical.

e) Special consideration shall be given protection against electrical noise and lightning.

f) The earthing requirements of the Manufacturer shall be followed.

g) Load cells shall be sealed air-tight and the terminal boxes shall offer protection to IP65.

h) Temperature compensation shall be incorporated.

11. TEMPERATURE

11.1 Temperature meters

11.1.1 General

The instruments shall be suitable for measuring temperature in containers and pipes. The temperature probes shall be suitable for use in hazardous areas (methane gas environment).

11.1.2 Operating principle

The temperature probes shall be of the RTD type complete with a suitable temperature transmitter.

11.1.3 Construction

a) The temperature transmitter shall be of the basic four wire type, with a separate 230 V AC supply and a galvanically isolated 4-20 mA output signal linearly proportional to the measured temperature.

b) The temperature transmitter shall be equipped with a digital local temperature indicator.

11.1.4 Installation

a) Where temperature is to be measured in large containers, e.g. digesters, thermometer pockets will be provided by others.

b) Where the temperature is to be measured in a pipe, a suitable thermowell shall be installed in the pipe to accommodate the temperature probe.

11.1.5 Accuracy

The accuracy of the temperature measurement shall be better than 1 % of full scale deflection.

11.2 Thermocouples

11.2.1 Thermocouples shall be:

a) Chromel-alumel (ISA Type K) for temperatures between -70 ºC and +900 ºC.

b) Platinum / 10 % rhodium platinum (ISA Type S) for temperatures in excess of 900 ºC.

11.2.2 All thermocouples shall be made from premium grade thermocouple wire.

11.2.3 Only thermocouples which are not grounded to the sheath shall be used.

11.2.4 Only duplex or triplex type thermocouples shall be used.

11.2.5 Thermocouple terminal heads shall provide the degree of protection against dust and moisture of IP 65. The heads shall be made of aluminium alloy.

11.3 Resistance temperature detectors

11.3.1 Three wire resistance temperature detectors (RTD) shall be used in applications where thermocouple performance can be influenced by electrical fields.

11.3.2 The choice between the use of thermocouples or RTF shall be based on the suitability for the application.

11.3.3 The choice for using RTD elements (100 Ω @ 0 ºC) shall be limited to temperatures of -175 ºC to +475 ºC. A duplex RTD platinum element shall have sealed windings within high purity alumina insulation with three leads per winding. The element shall be enclosed in a Type 316 stainless steel tube 6,3mm OD.

11.4 Temperature signal transmitters

11.4.1 The temperature signal to console mounted temperature instruments shall be converted to the standard analogue signal (4-20 mA). The following shall apply when temperature transmitters are used:

a) Cold junction compensation shall be done at the transmitter.

b) Radio frequency interference (R.F.I) protection shall be provided.

c) The output-signal shall be linear with respect to temperature.

d) Line resistant shall not affect signal accuracy.

e) The direction in which the transducer output must fail on element failure shall be specified.

11.5 Local temperature indicators

11.5.1 All local temperature indicators shall be adjustable angle, bimetallic actuated, 130 mm diameter dial thermometers with 6,3 mm OD stems. These shall not be installed more than 4 500 mm above grade or a platform. Installations above this height limit shall use remote reading gas or liquid filled thermal system thermometers with a 115 mm diameter indicator installed 1 700 mm above grade or on a platform.

12. INSTRUMENT FIELD WIRING SYSTEMS

12.1 General requirements

12.1.1 All wiring on instrument systems in hazardous areas shall meet the requirements of SANS 10108.

12.1.2 Shielded cable shall be used for all instrument signals of 90 V or less.

12.1.3 Shield and/or shield drain wires for individual pairs and inner overall shields of multi-pair cables shall have continuity from the sensing element to the control room or local panel. The shield on individual pairs shall be carried as an additional wire, isolated from earth with sleeving, wired through separate terminals, and connected to the high quality earth at the control room or panel only. The outer overall shield of multi-pair cables shall be connected to safety earth at the source end only.

12.1.4 Instrument wiring in control rooms shall generally consist of PVC insulated cables installed in trunking or tray, or bunched in control panels.

12.1.5 Field cables shall generally be one continuous run from service to destination but where junction boxes are required they shall enter and exit by the bottom gland plate.

12.1.6 Where instruments are installed in close proximity, instrumentation cables shall be reticulated to an instrumentation junction box, from where one multicore cable will be used to relay the various signals to the PLC.

12.1.7 Where possible, two sensors shall be wired to one transmitter.

12.1.8 Instrumentation cabling shall be run in wireways such as conduit and trunking. No open or loosely hanging instrumentation cables shall be allowed.

12.2 Wiring from instrument to junction box

12.2.1 All field mounted instruments shall be provided with single pair or triple cable installed on rigid supports providing protection against mechanical damage.

12.2.2 All wiring shall meet the electrical area classification requirements of the plant in which it is installed.

12.2.3 No splices shall be made in single pair or triple cables.

12.2.4 Stranded wires shall be connected to terminals with insulated pressure type lugs and each wire shall be marked at both ends with yellow fluorescent label material to indicate the terminal numbers.

12.3 Junction boxes

12.3.1 Field mounted junction boxes shall be provided for the termination of the single pair (or triple) cables and connection to multi-pair cables.

12.3.2 Only one multi-pair cable shall be allowed per junction box.

12.3.3 Junction boxes for outdoor use in non-hazardous areas, or for intrinsically safe systems in hazardous areas, shall be impact and corrosion resistant polyester boxes with terminal blocks and shall have hinged covers. All hinges and cover fasteners shall be corrosion resistant.

12.3.4 Explosion proof junction boxes shall have explosion proof combined breather and drain fittings at the bottom.

12.3.5 All cable runs shall enter junction boxes at the bottom or at the side within 200 mm from the bottom.

12.3.6 Cables between any junction box and control room shall be armoured multicore cables and can be routed above or below ground.

12.3.7 Each junction box shall be numbered and identified with a permanent nameplate.

12.3.8 Separate junction boxes and home run cables shall be provided for each voltage level and signal function.

12.3.9 Terminal blocks shall be sectional (barrier), two screw type for use with pre-insulated tip terminals, or screwless terminal blocks with cage clamp springs for all types of conductors used without terminal lugs.

12.3.10 Minimum spacing in junction boxes shall be 150 mm from terminal block to the side of the box and 150 mm between terminal block centrelines.

12.3.11 All junction points shall be permanently identified, both on the wire and on the terminal block. All terminals within a junction box shall be numbered consecutively. All field cables shall be tagged with the field instrument tag number and shall carry this number continuously to the control room.

12.3.12 All junction boxes shall have sufficient terminal blocks to terminate all cable pairs or triples including shield wire and spares.

12.4 Cable trays

12.4.1 Instrument cables where practicable shall be routed on separate trays from electrical power cables. Particular consideration shall be given to the requirement of specialist cables involving limits on resistance, capacitance and inductance, intrinsically safe electronic circuits and thermocouples.

12.4.2 The Contractor shall generally use existing cable trays, trenches or ducts showing particular consideration for cable types and their segregation requirements.

12.4.3 Vertically oriented cable trays are preferred to minimise fire hazards due to the accumulation of combustible dirt.

12.4.4 Cable trays containing 230 V AC power cables and cable racks containing instrument signal cables and thermocouple cable crossing each other, shall be separated by 100 mm.

12.5 Home run cables

12.5.1 Cabling between the field mounted junction boxes and the control rooms shall be multi-pair cables in overhead cable tray. Instrument leads and thermocouple leads shall not be run in the same multi-pair cable.

12.5.2 Instrument and thermocouple cables shall be isolated from power wiring according to the following directive:

a) In cable racks 230 V AC power cables shall be spaced 100 mm from instrument signal cables and thermocouple cables. In cases where 100 mm spacing cannot be achieved, a metal barrier fixed to the cable rack shall be installed between the 230 V AC power cables and instrument signal/thermocouple cables.

b) If it is required to join two cables on very long runs (more than 1 000m) the cables shall be brought to a connection box and connected through terminal blocks.

c) Multi-pair cables for instruments and thermocouples may be installed in the same tray or duct. Intrinsically safe cables may be installed in the same trays with other instrument and thermocouple cables.

12.5.3 When selecting a new multi-core cable on a project, one with the least standard number of cores possible shall be used. However, if the number of cores to be used exceeds 80 % of the capacity of the cable, then the next larger standard size shall be selected.

12.6 Fire protection of cables

12.6.1 Fire protection shall be provided for all power and signal cables in emergency service to afford a fire rating of half an hour life in the event of fire in process areas where fire hazards exist.

12.6.2 General process control and power cables not requiring fire protection, shall be segregated from the critical cables if there are economic benefits in having these categories of cable kept separate.

12.6.3 The preferred method of protection is direct burial of the cable to a point vertically below the emergency valve. The above ground cable shall be fire protected to afford half an hour life.

12.6.4 In the case where emergency valves are clustered sufficiently close together to justify the use of multi-core cable for the "home-run", a fire protected junction box shall be installed directly above grade. Field cable runs from the emergency valves to the junction box shall be fire resistant cable or be fire protected.

12.6.5 Should direct burial of emergency service cables prove impractical, above ground cables and cable trays with fire protection shall be installed.

12.6.6 Care shall be taken with regards to the insulation of cables buried in areas where spillage or gradual build-up of chemical products in the ground may occur.

12.6.7 Spare capacity in buried multi-core control cables shall be 33 %.

12.7 Interconnections

12.7.1 All materials required to interconnect or install instrument or electrical devices located on the package unit shall be supplied as part of the package (e.g. thermowells for thermocouples).

12.7.2 All interconnections between items supplied in the package unit (electrical, pneumatic, etc.) shall be supplied and installed by the Contractor.

12.7.3 All devices shall be pre-wired to a junction box, pre-piped, etc., except where shipping constraints necessitate dismantling of the unit, in which case interconnecting cables, pipe, tubing, etc., shall be clearly tagged for re-connection at the site.

12.7.4 Erection and assembly, and testing instructions shall be provided for and shall accompany any disassembled instrumentation or electrical equipment.

12.8 Instrument Signal Levels

12.8.1 Control voltage shall be 24 V DC for field device circuits and programmable controller inputs and outputs.

12.8.2 Signals to all programmable controller inputs shall be from isolated, voltage-free contacts capable of reliably switching 2A at 24 V DC.

12.8.3 The Contractor shall supply analogue instruments whenever possible with 4-20 mA signals.

12.8.4 All relay contacts shall be capable of reliably switching 2 A at 230 V AC and 24 V DC. Contacts shall be self-cleaning (wiping) action or be hermetically sealed. Where interposing relays are used the relay coil shall be rated for continuous operation.

12.8.5 Preference shall be given to loop-powered instruments wherever possible.

12.8.6 Four-wire instruments shall provide isolated signals where possible or shall incorporate a signal-isolating device.

12.8.7 Control system analogue inputs and outputs shall be isolated mA signals unless otherwise specified or agreed. Voltage inputs or outputs are generally not acceptable.

12.8.8 Any transducers required for signal conditioning and measuring devices with analogue outputs shall be smart loop powered devices with 4-20 mA outputs.

12.8.9 Low level (mV) signals shall be converted to 4-20 mA signals as close to the source as possible for field transmission (e.g. thermocouple).

12.8.10 Intelligent instruments (e.g. analysers) may communicate directly to a PLC utilising a communication bus protocol.

12.8.11 In summary, signal levels shall be used as listed in below:

Table 2: Signal Level Usage

Application	Signal Level
Analogue signals	4-20 mA (24 V DC)
Alarm Signals	24 V DC
Counters	24 V DC
Solenoid Valves	24 V DC
On-Off controls	24V DC
Status signals	24 V DC
Local pneumatic control	20 – 100 kPa (g)

13. PROCESS CONNECTION LOCATIONS

13.1 General

13.1.1 Instrument process connections shall be located for maximum convenience in operation and servicing of the instruments. The following general rules shall be adhered to, unless limited by other requirements in the design of a unit.

13.1.2 The location for installation of equipment shall be agreed on site with the Engineer, and shall be positioned not to restrict effective maintenance. Sensor cable joints shall be kept to minimum and where possible the length shall be continuous from sensor to transmitter.

13.2 Orientation of connections

13.2.1 Connections shall be oriented so that instruments or piping shall not obstruct aisles, platforms or ladders.

13.3 Field mounted transmitters

13.3.1 All field mounted transmitters shall be installed so that they are accessible from grade, platform or permanent ladders.

13.4 Control valves

13.4.1 Control valves shall be accessible from grade or platforms. A minimum of 250 mm shall be allowed between the top of the valve actuator and the underside of the nearest obstruction above it to permit the removal of internal parts. A minimum of 150 mm shall be allowed between the bottom side of valves and grade of platforms if the valve requires bottom access for maintenance.

13.5 Clearance for adjacent equipment

13.5.1 Clearance shall be provided at flow meter offices for valves or other components that may be located adjacent to the line.

13.6 Vessel connections

13.6.1 Connections on vessels for gauge glasses and level instruments shall be oriented to minimise the effect of inlet and outlet streams of the instruments.

13.7 Instrument accessibility

13.7.1 All instruments requiring adjustment shall be accessible for servicing from grade, walkways, permanent ladders, or platforms.

13.7.2 Flow meter primary devices, thermal system bulbs and thermocouples shall be accessible from walkways, permanent ladders, platforms or grade.

13.8 Instrument orientation

13.8.1 Instruments shall face the operating area so that the response to process adjustments can be observed from the operating area.

13.8.2 All instruments installed outdoors shall be installed so that the display faces south if practical.

14. DRAWINGS AND DOCUMENTATION

14.1 Drawings and design documentation

14.1.1 All drawings, information, and documentation shall be in the English language, 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. Drawings for acceptance shall be provided on A3 paper copies.

14.1.2 Three Operation Manuals, three Maintenance Manuals and three Certification copies shall be provided for all equipment supplied.

14.1.3 Manual formats shall be A4 size on the filing side which shall be vertical with 20 mm margin for filing.

14.2 Drawings and Documentation for Approval by the Engineer

14.2.1 The following documentation and drawings shall be submitted to the Engineer:

a) Prior to procurement

b) Detailed instrumentation list including tag number, supplier, ranges, location, signal, error signal and surge protection

c) General arrangement of instrumentation and control enclosures and junction boxes

d) Prior to installation

e) Hook-up and loop drawings

14.3 Operating & Maintenance Manual

14.3.1 The operating manuals shall include at least the following:

a) Manufacturer's name, address, telephone number and telefax numbers

b) A full technical specification of the equipment.

c) Full description and details of design capacity and design criteria for each item of equipment and each product

d) Detailed description of the function of all operator controls

e) Detailed description of all alarms, indications and protective devices

f) Detailed description of all adjustments

g) Operating instructions. These shall cover the different modes of operation and start-up/shut-down procedures

h) Relevant reduced drawings - general arrangements, assemblies, electrical schematics and parts lists

i) Procedures in case of a fault

j) Technical description of all components (Instrument Specification Sheets)

k) Maintenance instructions for all components and including repair, overhaul, change-out and installation procedures

l) Recommended inspections and frequency thereof

m) Schedules for running and shutdown maintenance

n) Spare parts information incorporating cross-section/"exploded" view drawings/illustrations with parts references/descriptions which provide clear reference to the Manufacturers part number and original manufacturer's name and part number when applicable.

o) All Process Equipment alarm and control parameters e.g. trip amp settings, control set points and control action values etc.

14.4 Certification

14.4.1 The testing results and certification shall include at least the following:

a) Suppliers acknowledgement of purchase order

b) Certification copies e.g. hazardous area classification

c) Pre-installation check sheets / Factory test certificate

d) Loop testing sheets

e) Acceptance certificate

f) Calibration test certificates

g) All "as built" design documentation

14.4.2 The Contractor shall guarantee that all products shall be suitable for the intended application and shall be capable of the duties specified.

14.4.3 The period for which the Contractor shall maintain the works in a perfect state of repair, order and condition shall be 12 months from the issue of the total plant taking-over certificate.

15. INSPECTION, TESTING AND CALIBRATION

15.1 General requirements for testing

15.1.1 Manufacturers that supply field instruments shall factory test and pre-assemble, fit accessories, tag, configure, calibrate and shop function test (including 24 hour burn in) instruments prior to delivery.

15.1.2 The Contractor shall be responsible for the commissioning of all services and equipment supplied and installed under the Contract. He shall provide proof of conformance and Manufacturer’s performance guarantees for the relevant equipment.

15.1.3 All work, activities, instrument serial numbers, adjustments, commissioning results, names of personnel, dates, times etc. shall be scheduled in an approved format throughout the duration of the works. The Contractor shall ensure that any system which he intends to operate is in a safe and ready condition.

15.1.4 The Engineer reserves the right to witness all or part of the works factory acceptance tests. At least 48 hours’ notice shall be given to the Engineer of any test. The accuracy of the test instruments and methods shall be demonstrated to the Engineer when required. The Contractor shall make available to the Engineer, copies of the relevant test sheets, prior to witnessing.

15.1.5 Official factory test/calibration certificates of all instrumentation shall be provided to the Engineer and included in the Operation and Maintenance Manual. Full factory traceability shall be available on request.

15.1.6 Any damage to plant or equipment during commissioning by the tests shall be rectified by the Contractor.

15.1.7 Any defects cause by poor workmanship, materials and performance maladjustments or other irregularities which become apparent during the testing and commissioning operations shall be rectified by the Contractor at his expense and the tests shall be repeated at the Contractor's expense to the satisfaction of the Engineer.

15.1.8 The Contractor shall ensure that all necessary spares are available on site during commissioning.

15.1.9 Four copies of final test results shall be issued to the Engineer in an appropriate and approved format

15.1.10 Instrument data sheets are to be ‘as built’ and material plus test (pressure, leak, hazardous area) certificates and calibration sheets are to be provided for each instrument in accordance with the data sheets.

15.1.11 The equipment shall be tested and commissioned together with the relevant pipework and other equipment such as pumps or compressors.

15.1.12 Prior to shipment the following shall be confirmed:

a) Standard manufacturer calibration and alignment tests of all instruments have been completed.

b) A parameter printout for electronic instrumentation is attached to the instrument calibration sheet.

15.1.13 Key non-standard set-up parameters shall be noted on the instrument data sheet.

15.1.14 A calibration sticker shall be placed on all shop tested and calibrated instruments.

15.1.15 The Contractor shall be responsible for all instrument calibration on site if the instrument requires adjustment or further calibration.

15.1.16 All cables shall be insulation and continuity tested before being connected at either end.

15.1.17 Wherever possible instrumentation once installed shall be fully checked and tested in service and test sheets completed.

15.1.18 After completion of installation, the Contractor shall provide evidence of the satisfactory operation of all equipment before the site acceptance certification be validated.

15.2 Visual checks

15.2.1 The Contractor shall carry out the following visual inspections to ensure that:

a) Terminals, cables, tubes, piping instruments and equipment have been identified and labelled.

b) Painting and protection against corrosion is complete.

c) Correct materials have been used.

d) Reticulation piping and equipment is adequately supported and accessible.

e) Installations are in accordance with the contract documents.

f) All connections are taped and tight.

g) All air supplies to instruments are on and pressure regulators are set correctly.

h) Impulse lines and air supply lines are leak tested. All pipe and tubing runs shall be pressure tested using air at 700 kPa and tested for leaks.

i) Particular attention is to be paid to the inspection of earthing to ensure that all equipment manufacturers' requirements are met.

j) Air lines are to be blown out with dry, filtered air before being connected to field devices

k) All cables tied in cable tray or installed in approved conduit.

15.3 Static tests - Instrument air supply lines

15.3.1 The following test shall be carried out:

a) Where possible, the line shall be disconnected at the instrument and blown through via the main instrument air supply. The line shall be reconnected and pressurised via the main instrument air supply and soap tested.

b) If it is not possible to use main instrument air to pressurise the line (i.e. downstream of a solenoid valve), bottled gas shall be used for the test in lieu of main instrument air.

c) If the pressure test will cause actuation of a final element the line shall not be reconnected after blow through. It shall be plugged and pressure tested.

d) The tested line shall be marked to indicate that it has been blown through and pressure tested. If main instrument air is used for these tests it shall be turned off when the test is completed.

15.4 Functional tests

15.4.1 Functional testing shall be conducted to confirm all equipment operates as per the Control Philosophy and the Test Sheets.

15.4.2 The Contractor will provide a Test Sheet for every loop. This sheet will show the tag number, instrument range, process signal spans, alarm settings, etc. for the instruments.

15.4.3 By performing functional tests the Contractor will show and record that all instrumentation when signalled, or excited performs the dynamical functions for which it was designed, and that all complete loops and all interconnections are correct.

15.4.4 The Contractor shall ensure that all field instruments and all control room instruments, or SCADA display belonging in the same loop, are functionally tested at the same time to prove the whole loop is correct.

15.5 Field Instruments

15.5.1 For transmitting instruments, a simulated process input of 0, 25, 50, 75 and 100 % both rising and falling shall be injected into the transmitter.

15.5.2 The transmitter shall be powered by the respective instrument power. The reading shall be noted for each input, and checked on the control System SCADA displays.

15.5.3 If a local indicator (4-20 mA) is in series with the transmitter, its reading shall also be recorded for each input. The transmitter and local indicator shall be adjusted if necessary until the output is within specification.

15.5.4 For receiving instruments, signals of 4 mA, 8 mA, 12 mA, 16 mA and 20 mA both rising and falling shall be injected via the control system. The output of the receiving instrument shall be adjusted if necessary until it is within specification.

15.5.5 Permission must be obtained prior to testing final elements. The final element shall be stroked open to close and the position noted for 0, 50 and 100 % signals. If main instrument air is used for these tests, it shall be turned off after the test is completed.

15.5.6 For switching instruments a simulated process input or mechanical actuation shall be applied and the alarm initiated. The switch shall be adjusted if necessary so that it operates at the correct setting, e.g.

a) Pressure switch: apply pressure equal to the set point

b) Flow switch: apply liquid flow equal to the set point

c) Level transmitter with alarm contact: raise the level to the set point

15.5.7 Switching valves shall be stroked open to close by energising and de-energising the respective solenoid valve. The results shall be recorded on the test sheet. Permission shall be obtained prior to testing switching valves.

15.5.8 For temperature signals the cable shall be disconnected and a resistance or mV signal shall be injected direct to the cable. All temperature sensors shall be checked for open or short circuit.

15.5.9 For magnetic type level gauges the float in the tube shall be moved up and down. The indication shall be checked for all possible positions.

15.5.10 All in line pressure instruments shall be subjected to non-destructive testing to the applicable piping code or vessel specification, including the following as a minimum in the absence of any other guide:

a) Pressure tests to 1.5 times the system design pressure at design temperature.

b) Radiographic testing of welds to detect all flaws (by a qualified operator).

15.5.11 In line instruments and control valves must be replaced by spools while process lines are cleaned and tested.

15.5.12 Thermocouple inputs shall be tested for correct burn out / open circuit response and indication. Unless otherwise specified, temperature transmitters shall be configured for upscale burnout.

15.6 Control Components

15.6.1 Where the package has no integral control system or control panel there shall be a complete test of all instrumentation from the point of interface (e.g. junction box for external connection).

15.6.2 All control valves shall be stroked without the positioner fitted to confirm bench set range and after the positioner is fitted to test the action of analogue and digital feedback signals.

15.6.3 Control valves and actuators are to be stroked over their entire range and feedback checks performed at 0, 25, 50 75 and 100 % of travel. Hysteresis checks are to be performed to ensure that process control requirements are met.

15.6.4 Function generators are to be used to test all inputs at the field end of input cables. i.e. mV, mA etc. At least three input signals shall be used. These are 0 %, 50 % and 100 % of range.

15.6.5 Control loops shall be tested to confirm control action and to ensure that the dynamic response is suitable for the process being controlled.

15.6.6 All sequence logic is to be tested to ensure correct operation of the process and to ensure that a malfunction at any time in the sequence shall not leave plant, equipment or personnel exposed to unsafe conditions.

15.6.7 All devices shall be tested to ensure that indications and alarms function correctly.

Aurecon South Africa (Pty) Ltd
1977/003711/07
Aurecon Centre
1 Century City Drive
Waterford Precinct
Century City
Cape Town
7441
PO Box 494
Cape Town
8000
South Africa
T +27 21 526 9400
F +27 21 526 9500
E capetown@aurecongroup.com
W aurecongroup.com

Aurecon offices are located in:
Angola, Australia, Botswana, Chile, China, Ethiopia, Ghana, Hong Kong, Indonesia, Lesotho, Libya, Malawi, Mozambique, Namibia, New Zealand, Nigeria, Philippines, Qatar, Singapore, South Africa, Swaziland, Tanzania, Thailand, Uganda, United Arab Emirates, Vietnam.

STANDARD SPECIFICATION

DWS 9900

SECTION C8

CORROSION PROTECTION OF ELECTRICAL EQUIPMENT

This document shall be read in conjunction with:

DWS 2020: Quality Assurance and Procedures

Annexures

Requirements to be specified
Departmental colour code

INDEX

PAGE

PAGE

PAGE

PAGE

PAGE

1. SCOPE

This specification covers the corrosion protection of plant and electrical equipment subjected to environments with variable corrosive tendencies.

2. INTERPRETATIONS

2.1 PROJECT SPECIFICATION

Plant and equipment shall be manufactured and corrosion protected in accordance with the requirements specified in the Project Specification. No deviation from specification will be allowed without the written consent of the Project Engineer. In the case of there being conflict between specifications, the Project Specification will take preference.

2.2 APPLICATION

This specification contains clauses that are generally applicable to the corrosion protection of plant and electrical equipment.

2.3 DEFINITIONS

COATING

Refers to the coating of specified items.

DIS-BONDED AREA

An area of coating that initially did adhere to the steel substrate after application, but which subsequently became loose from the substrate as a result of mechanical, chemical or other action.

UN-BONDED AREA

An area of coating which at no stage adhered to the steel substrate.

3. APPROVAL PROCEDURE

3.1 APPROVALS BEFORE AWARD OF CONTRACT

(a) The Corrosion Protection System specified in the Project Specification, shall be agreed upon between the Corrosion and Project Engineers.

(b) Approval by the Corrosion Engineer of the corrosion protection system, procedures and specific materials offered in the Tender. Manufacturer's data sheets or legible copies thereof shall be submitted for each product.

(c) Acceptance of the Departmental Quality Control Plan for Corrosion Protection - refer to DWS 2020 QCC1.

3.2 APPLICATION APPROVALS

(a) Qualification of personnel

(b) Quality of equipment

(c) Pre-preparation

(d) Surface preparation

(e) Application

(f) Final acceptance

4. GENERAL REQUIREMENTS

4.1 QUALITY ASSURANCE AND PROCEDURES

Quality procedures as specified in DWS 2020 shall be adhered to.

The production and application shall be in accordance with SABS ISO 9000, Quality System.

The Contractor shall ensure that he is fully conversant with the requirements of this specification and the relevant coating systems.

4.1.1 QUALITY PLAN

A detailed quality plan shall be submitted for approval and completion by the Corrosion Engineer before manufacture/coating is initiated – refer to DWS 2020 QCC1 section 1.

4.2 QUALIFIED STAFF

4.2.1 APPLICATION

A high standard of workmanship is required. Only experienced personnel shall be used to carry out corrosion protection work.

All work shall be carried out under the constant supervision of a qualified supervisor.

4.2.2 REPAIR WORK AT SITE

All repair work shall be done by competent personnel of the approved applicator under the supervision of a qualified supervisor.

4.3 COMPATIBILITY OF MATERIALS

The Contractor shall ensure that metals or alloys are compatible or are adequately protected if, in the galvanic series, there is more than 0,3 volt difference in the galvanic potential.

4.3.1 DESIGN PRECAUTIONS

All equipment shall be designed to suppress corrosion in an exposed environment.

4.3.1.1 ACCESSIBILITY

Easy access for protection and maintenance shall be provided. The use of back to back angles, partially open box sections or inaccessible stiffeners shall be avoided.

Corrosion protection of areas that are unavoidably inaccessible shall be specifically specified or approved by the Corrosion Engineer.

4.3.1.2 WATER RETENTION AREAS

Pockets, recesses and crevices in which water and dirt may collect shall be avoided. Water retention areas shall be properly drained by holes as large as possible i.e. 150 mm diameter – minimum 50 mm diameter.

Surfaces of corrodible metals, such as the insides of tanks or hollow sections that cannot be protected by any method (e.g. painting or dipping), shall be avoided, or where not possible, be fully sealed against ingress of air and moisture.

4.3.1.3 PERMANENT INSTALLATIONS

Permanent installations in concrete shall be manufactured from stainless steel as specified in Section 5.

4.3.2 CORROSION PREVENTION

The Contractor shall ensure that the following steps are taken to minimise corrosion:

(a) If dissimilar metals are used:

Coat all surfaces of the whole assembly including the more noble member of the galvanic series.

(b) If the noble member of the assembly cannot be entirely covered:

(i) Keep the anode/cathode ratio as large as possible in the particular component.

(ii) Use electrical insulators between two metals. Insulation must be complete, a bolt requires a sleeve as well as washers of an insulating material.

(c) Joints and crevices between metals shall be sealed.

(d) Where fastening is unavoidable, the fasteners shall be more noble (cathodic) than the base material. Fasteners shall be coated where possible and/or adequately electrically insulated between fasteners and the base material.

4.4 EQUIPMENT

4.4.1 MEASURING EQUIPMENT

The Contractor shall have the following measuring equipment at his shop or site at all times:

Ambient temperature gauge
Blast profile gauge
Dew point instrument
Dry film thickness gauge
Electric insulation defect detector
Surface temperature gauge
Relative humidity instrument
Wet film comb

All test equipment shall have current calibration certification.

All instruments shall be calibrated daily, except where otherwise specified by manufacturers, to achieve the required accuracy.

Dry film thickness gauges shall be calibrated on a flat surface, provided that the surface profile is in accordance with the specification.

4.4.2 SPRAY EQUIPMENT

Spray equipment shall be suitable for the production of high quality work, capable of properly atomising the coating material and equipped with suitable pressure regulators and gauges. Air caps, needles and nozzles shall be of the type recommended by the coating manufacturer.

All spray equipment shall be fitted with suitable oil and moisture traps.

4.4.3 MIXER

A low speed mixer, which does not introduce air into the coating material being mixed, shall be utilised.

4.5 INSTALLATION REQUIREMENTS

4.5.1 ANCHORS IN CONCRETE

All permanent anchors in concrete shall be stainless steel to ASTM A240 grade 316.

Special care shall be taken to ensure that anchors be installed to the correct level and depth. Anchors shall not be cut after installation without prior inspection and approval by the Engineer.

To avoid a galvanic reaction (stainless steel/galvanizing) under wet conditions, the nut and washer shall be FBE coated. Where necessary caps shall be specified by the Corrosion Engineer.

4.5.2 SEALING OF BASE PLATES

Where base plates are installed in high corrosive or humidity areas, edges of the grouting shall be sealed with a continuous polyurethane sealer approved by the Corrosion Engineer

4.6 HANDLING AND TRANSPORT

4.6.1 PHYSICAL PROTECTION

Adequate provision shall be made for the protection of the coating between the completion of manufacture and installation of items.

The coated items shall not be handled within the drying time recommended by the coating manufacturer, relevant to the ambient temperature.

4.6.2 LIFTING

All coated items shall only be lifted by means of broad band slings that will not damage the coating. Slings shall not be less than 50 mm wide or as approved by the Engineer.

4.6.3 TRANSPORT

Coated items shall be handled with due regard to the relatively soft nature of organic coatings and appropriate precautions shall be taken.

The Contractor is responsible for the safe delivery of all the items and small parts to site without damage. All items shall be securely packed to prevent damage while in transit.

If transported by a third party, the Contractor is responsible for ensuring protection of items as specified.

Precaution shall be taken to support and chock coated items in crates with saw-dust filled bags to prevent movement when loading onto vehicles.

Items shall be firmly lashed or chained with padded lashing. The area of padded surfaces shall be adequate to prevent damage to coatings.

Bolts in strong hessian bags and other small components shall be labelled and crated. The bags and crates shall be tagged using metallic tags and shall indicate the following information:

- Contract number,
- Scheme name,
- Part numbers,
- Description,
- Sizes,
- Quantities.

Each bag or crate shall have the delivery address listed on a separate metallic tag.

The Site Engineer shall be notified of the delivery date and of any requirements regarding off-loading and storage at site.

4.6.4 OFF-LOADING AT SITE

The supplier shall be responsible for the transportation and supervision during off-loading of equipment and other small components at the delivery site.

Under no circumstances shall coated equipment be allowed to rest directly on the ground.

The final delivery inspection and acceptance of equipment supplied shall be undertaken on site after off-loading has been completed.

4.6.5 STACKING AND STORAGE

The Contractor shall provide all the necessary balks of timber and sawdust bags used to support the items on soil, concrete or other hard surface and to separate them from each other, both at his works and on site.

Grass or other vegetation shall not be allowed to grow in the storage area within three metres of the equipment.

4.6.6 DAMAGE

Any damage that occurs during the handling and storage of items at the Manufacturer/Contractor's works, including transportation to site, shall be repaired by the Manufacturer/Contractor at his own cost, in accordance with the specification and to the approval of the Engineer.

4.6.7 REJECTION

The Engineer has the right to reject any damaged items and materials delivered and off-loaded at site.

5. RECOMMENDED COATING SYSTEMS

5.1 PROPRIETARY ITEMS

Components that are supplied painted or protected e.g. hoists, gearboxes, actuators etc. **shall only be accepted** provided that they meet the corrosion protection requirements of this specification. If this specification cannot be adhered to the Contractor **shall submit full details of the equivalent coating systems** at tendering stage for approval by the Corrosion Engineer.

5.2 COATING SYSTEMS FOR ELECTRICAL EQUIPMENT

Selection of all corrosion protection systems shall be cleared with the Corrosion Engineer before finalisation of the Project Specification.

The following tables are abbreviated guidelines and the systems are not listed in order of preference.

See **NOTES** under paragraph 5.4.

5.2.1 ELECTRICAL PANELS AND ENCLOSURES

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor – Dry	MS	1. Multi-purpose Epoxy plus Re-coatable Polyurethane if required	250 40
		2. Two pack Epoxy plus Re-coatable Polyurethane	250 40
		3. FBE	125
	PC ABS DCA	Un-coated	
	GRP	Polyester gelcoat	250
	3Cr12	1. Multi-purpose Epoxy plus Re-coatable Polyurethane if required	125 40
		2. Two pack Epoxy plus Re-coatable Polyurethane	125 40
		3. FBE	100
Indoor – Wet	3Cr12 or SS 304	1. Two pack Epoxy plus Re-coatable Polyurethane	250 40
		2. FBE	125
	DCA	FBE	75
	PC ABS	Un-coated	
	GRP	Polyester gelcoat	250
Outdoor	3Cr12 or SS 304	1. FBP	125
		2. Multi-purpose Epoxy plus Re-coatable Polyurethane if required	125 40

5.2.2 TRANSFORMERS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor and Outdoor	MS	Multi-purpose Epoxy	300

5.2.3 DIESEL GENERATOR

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor and outdoor	MS	Multi-purpose Epoxy – See note 8	300
	3Cr12	Multi-purpose Epoxy	150
	SS 304	Multi-purpose Epoxy	150
Items subjected to high temperatures		See note 9	

5.2.4 INDUSTRIAL SWITCHED SOCKET OUTLETS AND LIGHT SWITCH HOUSINGS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor – Dry	PVC	Un-coated	
	DCA	FBE	50
Indoor – Wet	PVC	Un-coated	
	DCA	FBE	75
Outdoor	DCA	FBP	75

5.2.5 CABLE SUPPORT SYSTEMS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Dry Not exposed to UV	MS	1. Two pack Epoxy	250
		2. Multi-purpose Epoxy	250
		3. FBE	150
		4. HDG	85
	3Cr12	Pickle and passivate – See note 4	
Dry Exposed to UV	MS	1. Two pack Epoxy plus Re-coatable Polyurethane	250 40
		2. Multi-purpose Epoxy	300
		3. FBP	150
		4. HDG	85
	3Cr12	Pickle and passivate – See note 4	
Wet	3Cr12	FBE	100
	SS 304 or SS 316	Pickle and passivate – See notes 3 and 4	

5.2.6 INDUSTRIAL LIGHT FITTINGS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor – Dry	MS	FBE	50
	DCA	FBE	50
Indoor – Wet	DCA	FBE	75
	GRP	Polyester gelcoat	250
Outdoor	DCA	FBP	75
	GRP	Polyester gelcoat	250

5.2.7 CONDUIT

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor - Dry	MS	HDG	65
	PVC	Un-coated	
Indoor - Wet	SS 304	Pickle and passivate – See notes 3 and 4	
	PVC	Un-coated	
Outdoor	MS	HDG	65
	SS 304	Pickle and passivate – See notes 3 and 4	
Underground	HDPE PVC	Un-coated	
	SS 304	Pickle and passivate – See notes 3 and 4	

5.2.8 JUNCTION BOXES

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor – Dry	DCA	FBE	50
	PVC	Un-coated	
	GRP	Polyester gelcoat	250
Indoor - Wet	DCA	FBE	75
	PVC	Un-coated	
	GRP	Polyester gelcoat	250
Outdoor	DCA	FBP	75

5.2.9 LIGHT POLES AND MASTS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor	GRP	Polyester gelcoat	250
	SS 304	Pickle and passivate – See note 4	
Outdoor	MS	HDG	105
	GRP	Polyester gelcoat	250
	3Cr12 SS 304	Pickle and passivate – See note 4	

5.3 FASTENERS, CABLE MOUNTING STRAPS AND CLAMPS

5.3.1 FASTENERS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Fasteners and washers (dry)	MS	HDG – plus threads coated with Molybdenum Disulphide lubricant or wax	45
	SS 304	Threads coated with Molybdenum Disulphide lubricant or Nickel Anti-seize compound	Uniform cover
Fasteners and washers (Wet/Submerged)	SS 316	1. Pickle and passivate (see note 3) – plus threads coated with Molybdenum Disulphide lubricant or Nickel Anti-seize compound	
		2. FBE coated (thread surfaces excluded) - plus threads coated with Molybdenum Disulphide lubricant or Nickel Anti-seize compound	50

5.3.2 ANCHORS

ENVIRONMENT	MATERIAL	SYSTEM	
Anchors in concrete (dry) See paragraph 4.5.1	SS 316	Threads coated with Molybdenum Disulphide Lubricant or Nickel Anti-seize compound	Uniform cover
Anchors in concrete (wet) See paragraph 4.5.1	SS 316	Threads coated with Molybdenum Disulphide Lubricant or Nickel Anti-seize compound plus nut and washer FBE coated	Uniform cover 50

5.3.3 CABLE MOUNTING STRAPS AND CLAMPS

ENVIRONMENT	MATERIAL	SYSTEM	MINIMUM DFT (µm)
Indoor	MS	HDG	45
	PVC	Un-coated	
	SS 304	Un-coated	
Outdoor	SS 304	Un-coated	

5.4 ABBREVIATIONS AND NOTES

Abbreviations

MS	:	Mild steel – grade 300WA
SS	:	Stainless steel – grades 304, 304L, 316 and 316L
3Cr12	:	Corrosion resistant steel
DCA	:	Die cast aluminium
PVC	:	Polyvinylchloride
HDPE	:	High Density Polyethylene
GRP	:	Glass fibre reinforced Polyester
ABS	:	Acrylnitrile-butadiene-styrene
PC	:	Polycarbonate
DFT	:	Dry film thickness
µm	:	Micrometer
FBE	:	Fusion-bonded Epoxy
FBP	:	Fusion-bonded Polyester
HDG	:	Hot-dip galvanized
UV	:	Ultra Violet

NOTES

The following items shall be approved by the Corrosion Engineer

1.	Multi-purpose Epoxy	-	Shall be suitable for immersion.
2.	Sealant	-	Interfaces of different environments shall be sealed with a Polyurethane flexible sealant applied in accordance with the manufacturers data sheets.
3.	Un-coated stainless steel	-	Only to be used if no galvanic reaction and anaerobic conditions are found.
4.	Pickle and passivate	-	If not in contact with less noble material.
		-	If exposed to anaerobic conditions seal-coat all crevices with Elastoplastic Epoxy.
		-	Shall be done by the dipping process.
5.	Galvanic cells	-	Where a galvanic cell is situated within a water path <150 mm and concrete cover <75 mm, both the MS, 3Cr12 or SS shall be coated.
6.	Mounting of electrical equipment	-	To be spaced 10 mm minimum from wall.
7.	Polyurethane for colour coding	-	Re-coatable or pure Aliphatic Polyurethane where required for colour coding. Only UV resistant Polyurethane shall be used.
8.	Fuel tanks	-	Only if not in contact with concrete or soil.
9.	Items subjected to high temperatures	-	Items to be manufactured out of stainless steel or coated with heat resistant paint.
10.	Anaerobic conditions	-	SS grade 316L shall be used under anaerobic and aggressive water conditions.
11.	Primers	-	Primers shall only be used in special cases i.e. over-coating of galvanized surfaces.

12. Epoxy primer - Epoxy primer may not be required if appropriate two pack Epoxy/ Re-coatable or pure Aliphatic Polyurethane is being used.

6 MANUFACTURE AND PRE-PREPARATION

6.1 RESPONSIBILITY

6.1.1 PRE-PREPARATION

The Manufacturer or Refurbisher shall be responsible for all the pre-preparation of equipment prior to surface preparation. Pre-preparation shall be carried out to the approval of the Corrosion Engineer and the Corrosion Protection Contractor.

6.1.2 PERSONNEL

Pre-preparation shall be carried out by competent personnel, under the supervision of an experienced supervisor.

6.1.3 MARKING

All items shall be permanently and indelibly marked to identify each individual item as specified by the Engineer.

6.2 FABRICATION REQUIREMENTS

6.2.1 SURFACE DEFECTS

All extrusions, rolled steel and castings shall be clean and free of score marks, pits, protrusions, blisters, porosity, blowholes, cracks or any other flaws which may be detrimental.

Laminations, scabs or occluded scale shall be ground out. If such grinding penetrates deeper than 7% of the metal thickness, the area shall be repaired by welding or the metal shall be rejected at the discretion of the Engineer.

6.2.2 UNDERCUTS, CAVITIES AND PITS

Weld undercuts and cavities as well as pits in metal surfaces are not permitted.

All undercuts, cavities and pits shall be ground out, re-welded and ground to a smooth contour.

6.2.3 WELDS

All welds shall be continuous and shall have a smooth contour.

Staggered welds, where specified, shall only be permitted with prior approval of the Corrosion Engineer on submission of appropriate remedial corrosion protection procedures.

Welding processes used shall limit heat input to a minimum to restrict the heat affected zone.

6.2.4 LIFTING LUGS

Where required, lugs shall be fitted by the manufacturer to the requirements of the Corrosion Contractor and the approval of the Engineer.

6.2.4.1 LUGS TO BE REMOVED

After removal the damaged coating area shall be repaired in accordance with the original Specification.

6.2.4.2 PERMANENT LUGS

Lugs, not intended to be removed, shall be manufactured of equal or more noble grade than the base material in accordance with the Specification.

6.3 REFURBISHMENT

6.3.1 INSPECTION PROCEDURE

Corrosion damage must be exposed by manual, mechanical or abrasive blast-cleaning for inspection. The refurbishment procedures shall then be specified by the Engineer.

6.3.2 PREPARATION METHODS

(a) Smooth out all shallow pits with a pencil grinder.

(b) Weld up and grind to a smooth finish where:

- More than 25% of the material has been lost by pitting corrosion.
- Material loss detrimentally affects the strength of the item.

(c) Replace damaged section.

6.4 PRE-PREPARATION

6.4.1 GENERAL REQUIREMENTS

6.4.1.1 PROTRUSIONS

Protrusions shall be removed by grinding and dressing to a smooth contour.

6.4.1.2 SHARP EDGES

Burrs and rough faces caused by guillotining, flame cutting, drilling, machining or punching shall be removed by grinding.

All sharp edges shall be radiused to a minimum of 2 mm.

6.4.1.3 WELDS

Welds shall be free from slag, slag inclusions, cracks, surface cavities and under-cuts.

Irregular projections shall be ground to a smooth contour.

Areas adjacent to welds shall be free from weld spatter. Such spatter shall be removed by grinding or scraping.

6.4.2 MATERIALS

6.4.2.1 CASTINGS

Castings with defects exceeding the restrictions given in the table below shall be rejected.

In the case of blowholes occurring opposite each other, the combined depth shall be taken into account.

Blowholes and cavities not exceeding 2 mm depth shall be smoothed out by grinding.

Acceptance criteria for the repair of blowholes and cavities.

SURFACE	DEPTH OF BLOWHOLES	DIAMETER OF BLOWHOLES	REPAIR
Internal	Maximum 20% of material thickness	40% maximum of material thickness	Welding only
External	Maximum 10% of material thickness	20% maximum of material thickness	Solvent free Epoxy or welding
External	10 to 20% maximum of material thickness	40% maximum of material thickness	Welding only

Castings shall, after inspection by the Engineer, be ground smooth.

Small and repaired blowholes shall be ground level and smooth.

6.4.2.2 HOT-DIP GALVANIZED ITEMS

The design and manufacture of all items to be hot-dip galvanized shall conform to SABS Code of Practice 0214.

Vent holes shall be drilled by the manufacturer, in accordance with the above Code of Practice, to the approval of the Engineer and Galvanizer.

The Silicon and Phosphorus contents of materials to be galvanized shall comply with the standard below. If no material certificates are available, samples of the materials shall be analysed for their Silicon and Phosphorus contents.

The following materials shall be used:

(a) For aesthetic appearance
- Aluminium-killed steel or
- Silicon-killed steel with a Silicon content not exceeding 0,04% and a Phosphorus content not exceeding 0,02%.

NOTE: Material certification shall be supplied.

b) For general corrosion protection
- Aluminium killed steel or
- Silicon killed steel with a Silicon content not exceeding 0,25% and a Phosphorus content not exceeding 0,02%.

6.4.2.3 CORROSION RESISTANT STEELS

Fabrication shall take place in dedicated areas separated from carbon steel.

All equipment used in the forming and manipulation of stainless steel items during fabrication shall be clean and free of materials that may contaminate the metal with carbon steel.

The manufacture of items from corrosion resistant steels shall be in accordance with the SASSDA's Information Series and the guidelines of the material supplier.

Discoloration caused by welding or cutting shall be mechanically cleaned by buffing followed by pickling and passivation in accordance with the SASSDA's Information Series and the guidelines of the material supplier.

Organic contamination shall be removed by degreasing.

Iron contamination shall be removed by pickling and passivation, by the dipping process, after degreasing.

All surfaces shall be tested for free iron contamination by the water or the ferroxyl test method.

6.5 PRIMARY CLEANING

The Manufacturer or Refurbisher shall remove excessive oil, grease or other surface contaminants with a water soluble solvent degreaser followed by rinsing with clean soft water before the items are despatched to the Corrosion Protection Contractor.

7 SURFACE PREPARATION

7.1 STANDARDS

SABS	1344	Medium duty solvent detergent.
SABS	064	The preparation of surfaces for coating.
SABS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after overall removal of previous coatings.
SABS ISO	8504-2	Preparation of steel substrates before application of paints and related products – Surface preparation methods – Part 2: Abrasive blast cleaning.
SABS Method	770	Cleanliness of blast-cleaned steel surfaces for painting (freedom of soluble salts).
SABS Method	772	Profile of blast-cleaned steel surfaces for painting (profile gauge).
SABS Method	769	Cleanliness of blast-cleaned steel surfaces for painting (freedom from dust and debris).
ISO	11125	Preparation of steel substrates before application of paints – Metallic blast-cleaning abrasives.
ISO	11127	Preparation of steel substrates before application of paints – Non-metallic blast–cleaning abrasives.

7.2 RESPONSIBILITY

7.2.1 SURFACE PREPARATION

The corrosion protection Contractor shall be responsible for preparation of all surfaces to be coated.

On completion of the Contract, all plant, equipment, temporary structures and materials shall be removed from the site.

7.2.2 PERSONNEL

The Contractor carrying out the surface preparation shall have competent personnel with the necessary technical knowledge of the processes involved.

All work shall be carried out under the supervision of an experienced supervisor.

7.2.3 EQUIPMENT

Plant and equipment shall, to achieve the specified surface preparation, comply with the following:

(a) Equipment and air supply free of oil and moisture.

(b) Compressors shall have a capacity and pressure output to achieve the required nozzle pressures.

(c) Worn nozzles shall be replaced.

If the correct surface preparation is not achieved due to inadequate plant and equipment, the Engineer may order the Contractor to obtain such plant and equipment as may be necessary to achieve the specified results.

All plant, equipment and temporary structures shall at all times be maintained in good and safe working order.

7.2.4 WORKING CONDITIONS

Surface preparation shall not take place when conditions are likely to affect the corrosion protection processes adversely.

The Contractor shall provide screens, covers, trestles or any other equipment necessary to avoid contamination of surfaces and to minimise time delays caused by inclement weather.

7.2.5 HEALTH AND SAFETY

The Contractor shall at all times enforce health and safety measures necessary to comply with the Occupational Health and Safety Act No. 85 of 1993 and the manufacturer's requirements.

7.3 PROCEDURE

7.3.1 APPROVAL OF WORKS AND PROGRAMME

The Contractor's programme, plant and equipment and works shall be approved by the Corrosion Engineer prior to commencement of surface preparation.

7.3.2 INITIAL INSPECTION

Before accepting items from the Fabricator, the corrosion protection Contractor shall check the initial condition of the surface for:

(a) Visible surface defects
(b) Corrosion or contamination
(c) Any required metal dressing
(d) Elimination of burrs and radiusing of edges
(e) Removing of weld spatter and weld imperfections such as blowholes
(f) Suitable lifting lugs

7.3.3 DEGREASING

All surfaces to be coated shall be tested for oil and grease contamination by the water break free test.

Oil and grease contamination shall be removed by:

- Steam-cleaning.
- An emulsifiable or aqueous detergent applied in accordance with SABS 1344.
- An alkaline cleaning solution.

Allow to react, then rinse off with clean, potable water to remove all residues prior to surface preparation, all in accordance with clauses 3.3 and 3.4 of SABS 064.

After degreasing, the surfaces shall be re-tested to show no oil, grease and chemical contamination.

Care shall be taken to avoid entrapment of cleaning agents in recesses or other retention areas.

7.3.4 ROUGH-BLAST

All rust, millscale, old coating or marking paint shall be removed by rough-blasting.

The Engineer shall be advised when blast-cleaning of the appropriate section will be completed so that an inspection can be carried out to determine if repairs are required.

Blast-cleaning shall be done in accordance with the code of practice SABS 064 to achieve a cleanliness of Sa 2 (SABS ISO 8501-1).

7.3.5 WATER SOLUBLE SALTS

The surfaces to be coated shall be tested for water soluble salts after blast-cleaning. The maximum level of salts allowable on the surfaces shall not exceed the values given in paragraph 7.4.1.

Should these values be exceeded, the surfaces shall be cleaned by:
(a) A liquid soluble salt remover approved by the Corrosion Engineer or
(b) Washing with a high pressure jet of clean potable water or
(c) Water injected blast-cleaning or
(d) Flash blast-cleaning until the soluble salts are within the specified limits.

7.3.6 FINAL-BLAST

7.3.6.1 FINAL-BLAST

7.3.6.1.1 Humidity and Temperature

All blast-cleaned surfaces shall be coated within:

Four (4) hours when humidity is less than 70% or

Two (2) hours when humidity is between 70% and 80%.

Final-blasting shall not be carried out if the steel temperature is less than 3°C above dew point.

7.3.6.1.2 Blasting Material

Final blast-cleaning shall be carried out using clean, uncontaminated blast-medium in accordance with paragraph 7.4.2.

7.3.6.1.3 Cleanliness

All surfaces for “wet/submerged conditions” and for “dry conditions” shall be blast-cleaned to Sa 3 and Sa 2½ respectively.

7.3.6.1.4 Profile

The required surface profile specified in paragraph 7.4.1 shall be achieved by final-blasting in accordance with SABS 064 and SABS ISO 8504-2.

7.3.6.1.5 Residual Dust and Debris

Prior to coating, dust and debris shall be removed by vacuum-cleaning in accordance with SABS 769 and paragraph 7.4.1. Dust and debris may only be removed by blowing with clean uncontaminated compressed air, with prior approval of the Corrosion Engineer.

7.3.6.1.6 Contamination

After final-blasting un-coated steel shall not be touched with bare hands. All applicators shall wear white gloves and shoe covers where applicable.

7.3.6.2 FLASH-BLAST

Flash blast-cleaning shall be carried out to reinstate the surfaces as specified in paragraph 7.4.1, in accordance with paragraph 7.4.1.

7.3.6.3 SWEEP-BLASTING

Sweep blast-cleaning is used to create a fine, even profile on soft materials and to remove portions of a coating.

The parameters for sweep blast-cleaning are as follows:

Equipment and air supply	Free of oil and moisture
Nozzle pressure	Not greater than 300 kPa
Nozzle angle to the surface being cleaned	30 to 60°
Sweeping distance	450 to 600 mm
Abrasive – ultra fine non-metallic grit	Minimum 0,2 mm – maximum 0,8 mm
Grit	Only new grit shall be used

7.4 REQUIREMENTS

7.4.1 SURFACE CONDITIONS

Prepared surfaces shall be in accordance with the table below.

PROPERTY	FOR DRY CONDITIONS	FOR WET/SUBMERGED CONDITIONS	TAPE WRAPPING
Cleanliness to ISO 8501-1 (min) (SIS 055900)	Sa 2½	Sa 3	St 2
Residual dust and debris (SABS Method 769)	0,5%	0,3%	0,5%
Oil, grease and perspiration	Nil	Nil	Nil
Surface Profile (min) Coats up to 200 µm (max)	30 µm 50 µm	30 µm 50 µm	- -
Surface Profile (min) Coats up to 300 µm (max)	50 µm 80 µm	50 µm 80 µm	- -
Surface Profile (min) Coats up to 500 µm (max)	60 µm 100 µm	60 µm 100 µm	- -
Water soluble salts: Maximum at any point. Average of any 250 cm.	 500 mg/m^2 100 mg/m^2	 100 mg/m^2 100 mg/m^2	 500 mg/m^2 100 mg/m^2

Note: Surface profile shall be about ↓ of the coating thickness.

7.4.2 ABRASIVE MATERIAL

7.4.2.1 MATERIAL

The blast-cleaning abrasive shall be composed of clean, sound hard particles free from foreign substances such as dirt, oil, grease, toxic substances, organic matter, water soluble salts and foreign metals.

7.4.2.2 CERTIFICATION

The abrasive material supplier shall certify that all products supplied conform to all the requirements specified.

7.4.2.3 SHAPE AND SIZE

The individual abrasive particles shall be angular in shape and within the following sizes:

Non-metallic material	0,2 to 0,8 mm or 0,4 to 1,4 mm
Metallic material	0,3 to 0,9 mm

7.4.2.4 HARDNESS

The minimum hardness of abrasive material shall be as follows:

For non-metallic material	6 on the Moh's scale
For metallic material	390 HV

7.4.2.5 PH

The pH of the prepared slurry mixture shall not be below 6,2.

7.4.2.6 WATER SOLUBLE SALTS

The conductivity of slurry shall be less than 25 mS/m in accordance with ISO 11127.

7.4.2.7 MOISTURE CONTENT

The moisture content for abrasive material shall not exceed 0,2 percent.

7.4.2.8 RE-CYCLING

Re-cycled blasting-material shall only be used if:

(a) Blasting-materials were only used on degreased surfaces
(b) Dust and debris is removed from the blasting-material
(c) Particles are kept angular and within specified sizes

7.4.3 AIR SUPPLY

The air pressure at the nozzle shall be a minimum of 600 to 700 kPa.

Air supply equipment shall be fitted with efficient oil and water traps to avoid contamination of the surface.

7.5 SURFACE PREPARATION OF OTHER MATERIALS

7.5.1 GALVANIZED SURFACES TO BE COATED

7.5.1.1 PASSIVATION

Surfaces to be coated shall **not** be passivated.

7.5.1.2 DEGREASING

Galvanized steel surfaces shall be degreased prior to coating, using either a water soluble solvent degreaser in accordance with SABS 1344 and the manufacturer's instructions, or a mild acid-detergent degreasing solution to be approved by the Corrosion Engineer.

7.5.1.3 PROFILE

7.5.1.3.1 Sweep-blasting

Large areas shall be prepared by sweep-blasting with non-metallic abrasive in accordance with paragraph 7.3.6.3. Cracking, flaking, or any form of delamination of the zinc coating due to excessive blast-cleaning shall not be permitted. Removal of zinc by blast-cleaning shall not exceed 10 µm.

7.5.1.3.2 Mechanical

Surfaces that can not be sweep-blasted shall be abraded manually or mechanically with abrasive paper grade 220 or by using non-metallic abrasive pads.

7.5.1.4 DUST AND DEBRIS

Finally, all dust and debris shall be removed by vacuum-cleaning.

7.5.1.5 PRIMER

Primer for galvanised surfaces shall be applied immediately after surface preparation, not exceeding the time limits specified in paragraph 7.3.6.1.1.

7.5.2 ALUMINIUM SURFACES TO BE COATED

Aluminium surfaces to be coated shall be treated as follows:

7.5.2.1 DEGREASING

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.2.2 PROFILE

Sweep-blast with non-metallic abrasive in accordance with paragraph 7.3.6.3.

7.5.2.3 DUST AND DEBRIS

All dust and debris shall be removed by vacuum-cleaning.

7.5.2.4 PRIMER

Primer for aluminium surfaces shall be applied immediately after surface cleaning, not exceeding the time limits specified in paragraph 7.3.6.1.1.

7.5.3 CORROSION RESISTANT AND STAINLESS STEEL

Components fabricated from stainless steel shall not be contaminated with iron or mild steel.

7.5.3.1 UN-COATED SURFACES

Stainless steel surfaces shall not be contaminated with carbon steel, scratched or stressed.

The following areas shall be pickled and passivated to remove all contamination and discolouration:

(a) All un-coated areas.

(b) Ground and sheared edges.

(c) Heat affected zones caused by welding or cutting.

It is recommended that, if possible, pickling and passivation be done by the dipping process.

Proprietary pickling and passivation chemicals (as supplied by approved suppliers) shall only be used in accordance with the manufacturer's recommendations. Care shall be taken not to exceed the maximum contact time recommended.

After pickling and passivation, surfaces shall be very thoroughly washed with clean potable water to remove all traces of acid. Surfaces shall be allowed to dry, then polished where necessary, using polishing compounds recommended by the stainless steel manufacturer.

7.5.3.2 SURFACES TO BE COATED

7.5.3.2.1 Degreasing

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.3.2.2 Profile

Corrosion resistant steel surfaces shall be blast-cleaned with stainless steel grit or non-metallic abrasive to create a profile in accordance with table 7.4.1. The use of steel shot and steel or cast iron grit is strictly prohibited.

Where blasting is impractical, the surface shall be roughened manually with abrasive paper grade 220, disc grinders or flapper wheel abrasive pads. In all instances, clean, uncontaminated equipment must be used.

Surface profile shall be in the range of 30 to 50 µm.

7.5.3.2.3 Dust and Debris

Dust and debris shall be removed by vacuum-cleaning.

7.5.4 SYNTHETIC MATERIALS TO BE COATED

7.5.4.1 DEGREASING

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.4.2 PROFILE

Abrade the surface with abrasive paper grade 220 to achieve a uniform matt finish.

7.5.4.3 DUST AND DEBRIS

Dust and debris shall be removed by vacuum-cleaning.

7.5.5 COATED SURFACES

7.5.5.1 PRIMED SURFACES TO BE OVER-COATED

7.5.5.1.1 Degreasing

Surfaces shall be degreased in accordance with paragraph 7.3.3.

7.5.5.1.2 Profile

Primers to be over-coated outside the over-coating period shall be abraded with abrasive paper grade 220 to a uniform matt finish.

All un-coated areas and all areas with micro rust shall be re-blasted to the original surface finish as specified.

7.5.5.1.3 Dust and Debris

Dust and debris shall be removed by vacuum-cleaning.

7.5.5.2 COATED SURFACES TO BE REPAIRED

Spot repairs shall be carried out in accordance with the original specification or as specified by the Corrosion Engineer. Repairs shall overlap the undamaged area by a minimum of 25 mm. Repairs shall be built up to the original undamaged coating thickness.

7.5.5.2.1 Preparation of Bare Areas.

Bare areas shall be prepared by spot-blasting to Sa 3 in accordance with paragraph 7.3.6. If spot-blasting is not possible, clean with abrasive paper grade 220 to a bright metal surface.

7.5.5.2.2 Soluble Salts

The surfaces shall be tested for water soluble salts in accordance with paragraph 7.3.5.

7.5.5.2.3 Feathering of Coated Surfaces

The surrounding paint, which must be intact, shall be feathered for a minimum distance of 25 mm beyond the damaged areas.

7.5.5.2.4 Dust and Debris

Dust and debris shall be removed by vacuum-cleaning.

7.5.5.3 COATED SURFACES TO BE OVER COATED

7.5.5.3.1 Degreasing

Surfaces shall be cleared of all contamination and degreased in accordance with paragraph 7.3.3.

7.5.5.3.2 Profile

Coated surfaces to be over-coated outside the over-coating period shall be abraded with abrasive paper grade 220 to a uniform matt finish.

7.5.5.3.3 Dust and Debris

Dust and debris shall be removed by vacuum-cleaning.

7.5.5.3.4 Solvent-wiping

The surfaces to be coated shall be wiped with the solvent specified by the coating manufacturer and approved by the Corrosion Engineer.

Further coats shall then be applied as specified in the Project Specification.

7.6 TEST METHODS

Tests, instruments, methods and criteria shall be as specified below or in the Project Specification.

7.6.1 FREE OF OIL AND GREASE

7.6.1.1 WETTING WITH WATER

All surfaces cleaned of oil and grease shall be tested using the “water-break-free” method. The surface shall be wetted with water and the entire surface shall be covered by an unbroken film.

7.6.1.2 SOLVENT-WIPING

Where water soluble lubricants may be present the surface shall be further tested by wiping with a clean cotton wool swab soaked in solvent. No stain shall be evident on the swab after solvent-wiping.

7.6.2 WATER SOLUBLE SALT CONTAMINANTS

Substrate surfaces shall be tested for the presence of water soluble salt contaminants in accordance with SABS Method 770 or by means of the Weber Reilly Test.

7.6.3 STANDARD OF MECHANICAL SURFACE PREPARATION

Mechanical surface preparation shall be visually compared to the standard shown in SABS ISO 8501-1.

7.6.4 BLAST PROFILE

The blast profile of the substrate surfaces shall be determined in accordance with SABS Method 772.

7.6.5 RESIDUAL DUST AND DEBRIS

Substrate surfaces shall be tested for the presence of residual dust and debris in accordance with SABS Method 769.

7.6.6 BLASTING-MATERIAL

All blasting-materials shall be approved by the Corrosion Engineer.

7.6.6.1 METALLIC ABRASIVE

Abrasive shall be tested in accordance with ISO 11125 for particle size, hardness, density, foreign matter and moisture.

7.6.6.2 NON-METALLIC ABRASIVE

Abrasive shall be tested in accordance with ISO 11127 for particle size, hardness, density, moisture and water soluble contaminants.

8 EPOXY COATING SYSTEM

8.1 STANDARDS

Equipment, materials and operational methods shall comply with the relevant SABS, ISO, BS, DIN or equivalent American Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SABS	1091	National colour standards for paint.
SABS	1217	The production of painted and powder coated steel pipes.
SABS Method	769	Cleanliness of blast-cleaned steel surfaces for painting (dust and debris).
SABS Method	772	Profile of blast-cleaned steel surfaces for painting.
SABS ISO	2808	Determination of film thickness.
SABS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
BSS	5493	Protective coating of iron and steel structures against corrosion.
SABS ISO	9000	Model for quality assurance in production and installation.

8.2 MATERIAL

(a) The Contractor shall have the latest editions of all the relevant National Specifications and Codes of Practice and the manufacturer's data sheets of materials to be used available

(b) Two pack Epoxies shall be in accordance with SABS 1217. Preference will be given to Contractors utilising solvent free Epoxies in confined spaces.

Two pack Epoxies offered shall be either polyamide or polyamine cured.

(c) Multi-purpose Epoxy shall be of the high build, modified aluminium Epoxy mastic type, containing at least 90% solids.

(d) Materials and procedures shall comply with the relevant SABS Specifications and Codes of Practice.

(e) All materials in a coating system shall be purchased from the same manufacturer unless approved by the Corrosion Engineer.

(f) Details of coating materials to be supplied for approved – refer to paragraph 3.1. The Contractor shall only proceed with the purchase of coating materials upon receipt of written approval from the Corrosion Engineer.

(g) Materials offered and subsequently approved shall not be changed without written approval of the Corrosion Engineer.

Coating material selection shall also be approved by the material manufacturer/supplier. The Contractor shall receive a written assurance from the material suppliers that the materials comply with the specified requirements.

(h) All coating materials shall be delivered in the manufacturer's original containers, clearly marked with the following:

- Manufacturer's name
- Product Brand and Reference Number
- Batch Number which may incorporate the date of manufacture
- Abbreviated instructions for storage and use of material, which shall include mixing ratios of the components of multi-component materials, minimum and maximum temperature of application and the method of application
- The SABS mark where applicable

(i) All coating materials shall be kept in an approved dry and enclosed store. The temperature shall not drop below 0°C nor exceed 40°C.

(j) Usage of materials shall be on a first in, first out basis and no materials shall be used that have exceeded the shelf life recommended by the manufacturer.

8.3 SPECIAL COATING AREAS

(a) Areas that are inaccessible after assembly shall be prepared and fully coated with the specified system to the specified requirements before assembly. The coating shall be fully cured before assembly.

(b) Mating surfaces of joints shall be coated with primer (where specified) or first coat only. The coating shall be uniform in thickness and shall not interfere with the mechanical tolerances. After assembly the outside surface of the joints shall be fully coated.

(c) Steel edges to be welded after coating shall not be coated for a distance of 50 mm from the welding edge. The unlined strip of grit blasted surface shall be temporarily protected with a coat of (red or a different colour to the lining/coating) weldable primer between coating application and installation.

(d) Friction grip areas shall be left un-coated unless otherwise specified.

8.4 APPLICATION

8.4.1 ACCEPTABILITY OF ITEMS TO BE COATED

Shall conform to sub-clause 4.1.1 of SABS 1217, with the proviso that pipes shall read items to be coated.

8.4.2 SURFACE PREPARATION

The Contractor shall satisfy himself that the condition of each item to be coated is such that it is fit for coating or lining, or both, as relevant. Immediately after surface preparation each item or special shall be examined, including the inside surface, where possible, for compliance with the relevant requirements of this sub-clause.

Pre- and surface preparation shall conform to Sections 6 and 7 respectively.

8.4.3 COATING THICKNESSES

Coating thicknesses shall conform to Section 5 or as specified in the Project Specification.

8.4.4 MANUFACTURER'S INSTRUCTIONS

Recommendations supplied by the manufacturer in the form of the latest edition of printed data sheets, or given in writing on the manufacturer's letterhead, shall be followed.

The following details shall be made available to the applicator:

(a) Brand and type of epoxy resin
(b) Mixing and thinning instructions
(c) Recommended type and quantity of solvent required for thinning during application
(d) Pot life of mixed product
(e) Minimum and maximum recommended dry film thickness per coat
(f) Recommended time intervals between coats
(g) Recommended minimum and maximum steel surface temperatures during application
(h) Time for complete drying and curing on steel surfaces
(i) All relevant information the supplier wishes to submit on his product
(k) Recommended method of coating application

Verbal information by the manufacturer's representative will not be accepted unless confirmed in writing by the Company.

8.4.5 COATING APPLICATION

8.4.5.1 ENVIRONMENTAL CONDITIONS

8.4.5.1.1 Dusty Conditions

Coatings shall not be applied in dusty or contaminated conditions.

8.4.5.1.2 Surface Temperature

Coatings shall not be applied if the surface temperature of the steelwork is less than 3℃ above dew point or outside the range 5-40℃, unless otherwise specified by the coating manufacturer.

8.4.5.1.3 Relative Humidity and Time of Application

The first coat shall be applied as soon as possible after blast cleaning, but not exceeding four (4) hours if the relative humidity (RH) is below 70% or two (2) hours if the RH is between 70% and 85%. Refer to paragraph 7.3.6.1.

8.4.5.1.4 Ambient Temperature

Coatings shall not be applied when the ambient temperature is less than the minimum or greater than the maximum specified by the manufacturer of the coating material.

8.4.5.2 MIXING

The Contractor shall ensure that all paints are mixed in accordance with the requirements of Specification BS 5493.

All coating components, particularly two- or multi-component materials, shall be thoroughly mixed until a homogeneous mixture is achieved.

In the case of two-pack materials, each component containing pigments shall be thoroughly mixed. The two components shall then be mixed together in the proportions supplied by the Manufacturer until the mixture is completely homogeneous. For two pack materials, the use of part of the contents (split packs) is strictly forbidden unless the components can be accurately measured to within 0,5% of material by volume. Splitting of packs will only be accepted if measurement of components is done by the use of a laboratory volume beaker (0-1000 ml) and mixed in the precise volume specified by the manufacturer.

In the case of solvent based Epoxy materials, it is recommended that the mixed material be allowed to stand for an induction period, as recommended by the manufacturer, before use.

During application, coating materials shall be agitated regularly to keep the solids in suspension. The preparation time, induction time and pot life of these materials shall be closely adhered to.

8.4.5.3 APPLICATION REQUIREMENTS

8.4.5.3.1 Equipment

Application equipment shall be maintained in a clean condition and in good working order.

The use of equipment not maintained in good condition may lead to rejection of the coating.

8.4.5.3.2 Compatibility of Coats

All primer, intermediate and finishing coats shall be mutually compatible.

8.4.5.3.3 Surface Restoration

Should immediate lining/coating not be possible, or should any atmospheric oxidisation take place between the completion of blast cleaning and commencement of lining/coating, such oxidisation shall be removed by flash blasting to restore the specified surface finish. Removal of dust and debris shall be in accordance with paragraph 7.3.6.1.5.

8.4.5.3.4 Supports

During coating application, the items shall be so supported to prevent damage to the wet coatings until the coatings have hardened adequately. Items shall remain supported during curing, storing and handling.

8.4.5.4 METHOD OF APPLICATION

8.4.5.4.1 Application

Epoxy coatings shall be applied by any appropriate method recommended by the manufacturer thereof, and approved by the Corrosion Engineer.

8.4.5.4.2 First Coat

The first coat shall be applied to a minimum dry film thickness of 40 µm above the peaks of the blast profile.

8.4.5.4.3 Cleanliness

During application and curing of the layers, the items shall be protected against contamination by dust or other foreign matter and shall be kept dry and shaded from direct sunlight.

All coats shall be clean and free from dust, oil, moisture and perspiration before over-coating.

Operators handling blast-cleaned or partially painted surfaces shall wear clean gloves to avoid contamination of the surface.

8.4.5.4.4 Stripe Coat and Crevices

All metal edges, welds, bolts and nuts shall be adequately coated. Stripe coats shall be applied after the first coat.

Special attention shall be given to crevices and edges to ensure complete coverage and uniform paint thickness.

8.4.5.4.5 Second and Subsequent Coats

The second and subsequent layers shall then be applied within the recommended over-coating periods.

8.4.5.4.6 Coat Colours

The colour of each subsequent coat shall be different to that of the previous coat except where two finishing coats of the same colour are necessary to achieve colour uniformity.

8.4.5.4.7 Over-coating Times

Over-coating times shall be not less than the minimum, nor greater than the maximum specified by the manufacturer relevant to the ambient temperature.

Strict adherence to over-coating times is particularly important for coatings which are subsequently immersed.

8.4.5.5 OVER-COATING WITH POLYURETHANE

8.4.5.5.1 Wet, Submerged or High Humidity Conditions

Pure Aliphatic Polyurethane

(a) The area to be over-coated shall be abraded with abrasive paper grade 220 to a uniform matt finish.

(b) The surface shall be vacuum-cleaned to remove dust and debris – refer paragraph 7.3.6.1.5.

(c) Contaminants shall be removed and surfaces prepared by wiping with an organic solvent.

(d) Over-coat with a 25 to 35 µm layer of pure Aliphatic Polyurethane in accordance with the Departmental colour code.

8.4.5.5.2 Dry or UV Conditions

Re-coatable Polyurethane

(a) The area to be over-coated shall be abraded with abrasive paper grade 220 to a uniform matt finish.

(b) The surface shall be vacuum-cleaned to remove dust and debris – refer paragraph 7.3.6.1.5.

(c) Over-coat with a 40 µm minimum layer of Re-coatable Polyurethane in accordance with the Departmental colour code.

8.4.5.6 QUALITY OF COATING

8.4.5.6.1 Finish

The fully cured coating shall have a uniform, smooth, gloss finish with proper adhesion.

8.4.5.6.2 Dry Film Thickness (DFT)

The Epoxy coating shall be evenly applied to the minimum final film thickness as specified in section 5 and shall be tested in accordance with paragraph 8.5.4.

8.4.5.6.3 Electrical Insulation Defects

All coated surfaces intended for water immersion or where likely to be frequently wetted under normal service conditions shall show no electrical insulation defects when tested in accordance with paragraph 8.5.3.

8.4.5.6.4 Finishing Coat Colours

The finishing coat colours shall be as specified in the Project Specification in accordance with the Departmental Colour Code.

Colours shall be in accordance with SABS 1091.

Where not specified, the selection of final colours shall be approved by the Engineer.

8.4.5.6.5 Solvent Entrapment

Coatings showing evidence of entrapped solvents after full cure will be rejected. No inter-coat de-lamination shall be allowed.

The Contractor shall be held responsible for blistering of coatings, when shown to be caused by solvent retention.

8.5 TESTING

To be read in conjunction with paragraph 4.1, Quality Assurance.

8.5.1 CONTRACTOR'S AND ENGINEER'S INSPECTIONS

Paragraphs 1.4 and 3.1 of DWS 2020 shall apply.

8.5.2 VISUAL INSPECTION

All surfaces shall be inspected visually and shall be free from tears, runs, sags, wrinkles, blisters, change in colour or gloss, orange peel, dirt, visible pinholes, dust or fluff occlusions or any other visible defects.

8.5.3 HOLIDAY INSPECTION (ELECTRICAL INSULATION DEFECTS INSPECTION)

100% of all coated surfaces shall be tested and there shall be no electrical insulation defects on any area inspected.

Except for coatings containing conductive pigment (Zn, Al), low-voltage wet sponge electrical insulation defects inspection shall be carried out in accordance with SABS 1217 for coated surfaces not exceeding 500 µm.

Inspection procedure shall ensure that sufficient moisture is present at all times.

For films exceeding 500 µm thickness, a high voltage, electrical insulation defects detector shall be used in accordance with SABS 1217.

8.5.4 DRY FILM THICKNESS (DFT)

(a) Measurements shall be taken in accordance with SABS ISO 2808.

(b) 100% of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) In the case of coats applied after the erection of steel work on Site, the number of DFT measurements taken shall be at the discretion of the Engineer's Inspector or the Engineers Representatives.

(d) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the paint film is demonstrated to be sound in all respects.

(e) Owing to delayed solvent release, solvent-borne coatings shrink over a period of time resulting in a lower film thickness and therefore it is important that DFT measurements be taken within seven days.

DFT measurements taken at times beyond seven days after application, shall not constitute a valid claim against the original satisfactory and documented execution of the work.

(f) The method used to measure DFT, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

8.5.5 DEGREE OF CURE OF TW0-COMPONENT MATERIALS

The degree of cure of a two-component material will vary with time, temperature and ventilation and shall be assessed by solvent wiping in accordance with the method given in SABS 1217 (methyl ethyl ketone resistance test)

8.6 DAMAGED COATINGS

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures as set out in paragraph 8.5.1.

Where the damage is extensive the remedial procedures shall be agreed in writing with the Corrosion Engineer.

(b) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(c) Any damage occurring during transit from the Contractor's premises to site, shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment on site shall repair any damage occurring on site during handling, assembly, storage, transport and erection.

(d) The repaired area shall be tested in accordance with sub-clauses 8.4 and 8.12 of SABS 1217 for compliance with the relevant requirements for thickness and electrical insulation defects respectively.

(e) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be repaired. The item shall be blast cleaned and re-coated in accordance with the relevant requirements of the specification

8.7 REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a medium grade 220 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SABS method 769 and paragraph 7.4.1.

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry

(e) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: 1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.

2. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

8.8 REPAIR METHODS FOR MAJOR DEFECTS

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Blast-clean all damaged areas to Sa 3 (SABS ISO 8501-1).

(c) Feather the surrounding paint for a distance of 25 mm beyond the damaged areas with a medium grade 220 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SABS method 769 and paragraph 7.4.1.

(e) Wipe only the abraded paint surface with methyl ethyl ketone and allow to dry.

(f) Apply as many coats of repair material as necessary to achieve the specified thickness and finish.

NOTE: 1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.

2. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

9 FUSION BONDED EPOXY COATING SYSTEMS

9.1 FUSION-BONDED EPOXY COATING (HEAVY DUTY)

9.1.1 STANDARDS

Equipment, materials and operational methods shall comply with the relevant SABS, ISO, BS, DIN or equivalent American Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SABS	1217	The production of painted and powder coated steel pipes.
SABS Method	769	Cleanliness of blast-cleaned steel surfaces for painting (dust and debris).
SABS Method	772	Profile of blast-cleaned steel surfaces for painting.
SABS ISO	2808	Determination of film thickness.
SABS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
BSS	5493	Protective coating of iron and steel structures against corrosion.
SABS ISO	9000	Model for quality assurance in production and installation.

9.1.2 MATERIAL

Shall conform to SABS 1217, Type 2, powder coating.

9.1.3 APPLICATION

9.1.3.1 SURFACE PREPARATION

Pre- and surface preparation shall conform to Sections 6 and 7 respectively.

9.1.3.2 COATING THICKNESSES

Coating thicknesses shall conform to Section 5 or as specified in the Project Specification.

9.1.3.3 COATING APPLICATION

Items shall be heated to a temperature of 200°C (only applicable to heavy items) and coated with Fusion-bonded Epoxy by means of an electrostatic powder gun.

The normal procedures pertaining to powder application shall apply.

On completion of the coating, items shall be cured for 60 minutes at 200°C (mean temperature).

9.1.3.4 QUALITY OF COATING

9.1.3.4.1 Finish

The fully cured coating shall have a uniform, smooth, gloss finish with proper adhesion.

9.1.3.4.2 Film Thickness

The Epoxy coating shall be evenly applied to the minimum final film thickness as specified in section 5 and shall be tested in accordance with paragraph 9.1.4.4.

9.1.3.4.3 Electrical Insulation Defects

All coated surfaces intended for water immersion or where likely to be frequently wetted under normal service conditions shall show no electrical insulation defects when tested in accordance with paragraph 9.4.4.3.

9.1.3.4.4 Finishing Coat Colours

The finishing coat colours shall be as specified in the Project Specification in accordance with the Departmental Colour Code.

Colours shall be in accordance with SABS 1091.

Where not specified, the selection of final colours shall be approved by the Engineer.

9.1.4 TESTING

To be read in conjunction with paragraph 4.1, Quality Assurance and SABS 1217.

9.1.4.1 CONTRACTOR'S AND ENGINEER'S INSPECTIONS

Paragraphs 1.4 and 3.1 of DWS 2020 shall apply.

9.1.4.2 VISUAL INSPECTION

All surfaces shall be inspected visually and shall be free from tears, runs, sags, wrinkles, blisters, change in colour or gloss, orange peel, dirt, visible pinholes, dust or fluff occlusions or any other visible defects.

9.1.4.3 HOLIDAY INSPECTION (ELECTRICAL INSULATION DEFECTS INSPECTION)

100% of all coated surfaces shall be tested and there shall be no electrical insulation defects on any area inspected.

Inspection procedure shall ensure that sufficient moisture is present at all times.

For films exceeding 500 µm thickness, a high voltage, electrical insulation defects detector shall be used in accordance with SABS 1217.

9.1.4.4 FILM THICKNESS

(a) Measurements shall be taken in accordance with SABS ISO 2808.

(b) 100% of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) Film thickness in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the coating is demonstrated to be sound in all respects.

(d) The method used to measure film thickness, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

9.1.4.5 DEGREE OF CURE OF FUSION-BONDED MATERIALS

The degree of cure of fusion-bonded material shall be assessed by solvent wiping in accordance with the method given in SABS 1217 (methyl ethyl ketone resistance test)

9.1.5 DAMAGED COATINGS

(a) All repairs and procedures shall be approved by the Corrosion Engineer and subject to inspection procedures as set out in paragraph 8.5.1.

Where the damage is extensive the remedial procedures shall be agreed in writing with the Corrosion Engineer.

(b) All repairs shall comply with the requirements of the repair-product manufacturer's data sheet. The Engineer may at his discretion request that repaired coating areas undergo adhesion tests.

(c) Any damage occurring during transit from the Contractor's premises to site, shall be the responsibility of the Contractor. The Contractor responsible for installation of equipment on site shall repair any damage occurring on site during handling, assembly, storage, transport and erection.

(d) The repaired area shall be tested in accordance with sub-clauses 8.4 and 8.12 of SABS 1217 for compliance with the relevant requirements for thickness and electrical insulation defects respectively.

(e) Any item showing electrical insulation defects exceeding an average of five per square metre (a cluster of pinholes within a radius of 25 mm being regarded as a single defective area), or flaking or other signs of loss of adhesion, shall not be repaired. The item shall be blast cleaned and re-coated in accordance with the relevant requirements of the specification

9.1.6 REPAIR METHODS FOR MINOR DEFECTS

The repair of areas showing electrical insulation defects or low film thickness shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with a medium grade 220 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with paragraph 7.4.1.

(d) Wipe the abraded paint surface with methyl ethyl ketone and allow to dry

(e) Apply as many coats of the following repair material as necessary to achieve the specified thickness and finish.

(i) Solvent free Epoxy or

(ii) Fusion-bonded Epoxy powder repair kit.

NOTE: 1. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

9.1.7 REPAIR METHODS FOR MAJOR DEFECTS

The total un-coated areas for renovation by the applicator shall not exceed 0,5 percent of the total surface area of a component. Each un-coated area for renovation shall not exceed 2 500 mm^2. If damaged areas are larger, the items containing such areas shall be re-coated.

The repair of areas showing damage down to the steel surface shall, if approved by the Corrosion Engineer, be carried out as follows:

(a) Degrease in accordance with paragraph 7.3.3.

(b) Blast-clean all damaged areas to Sa 3 (SABS ISO 8501-1).

(c) Feather the surrounding paint for a distance of 25 mm beyond the damaged areas with a medium grade 220 abrasive paper.

(d) Vacuum-clean the surface to remove dust and debris in accordance with SABS method 769 and paragraph 7.4.1.

(e) Wipe only the abraded paint surface with methyl ethyl ketone and allow to dry.

(f) Apply as many coats of the following repair material as necessary to achieve the specified thickness and finish.

   (i) Solvent free Epoxy or

   (ii) Fusion-bonded Epoxy powder repair kit.

NOTE: 1. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

9.2 POWDER COATINGS AS SPECIFIED IN SABS 1274

9.2.1 STANDARDS

Equipment, materials and operational methods shall comply with the relevant SABS, ISO, BS, DIN or equivalent American Standard.

The Contractor shall ensure that he is in possession of the latest editions of all the relevant National Specifications, Codes of Practice or Standards referred to in this specification.

Reference is made to the latest issues of the following Standard Specifications:

SABS	064	The preparation of steel surfaces for coating
SABS	1217	The production of painted and powder coated steel pipes.
SABS	1274	Coatings applied by the powder-coating process.
SABS Method	769	Cleanliness of blast-cleaned steel surfaces for painting (dust and debris).
SABS Method	772	Profile of blast-cleaned steel surfaces for painting.
SABS ISO	2808	Determination of film thickness.
SABS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
BSS	5493	Protective coating of iron and steel structures against corrosion.
SABS ISO	9000	Model for quality assurance in production and installation.

9.2.2 MATERIAL

Shall conform to SABS 1274, Type as specified in the Project Specification.

9.2.3 APPLICATION

9.2.3.1 SURFACE PREPARATION

Pre- and surface preparation shall conform to Sections 6 and 7 respectively.

If abrasive blast-cleaning is not practical, a surface conversion hot applied coating in accordance with SABS 064, Section 5 shall be applied.

9.2.3.2 COATING THICKNESSES

Coating thicknesses shall conform to Section 5 or as specified in the Project Specification.

9.2.3.3 COATING APPLICATION

The coating shall be applied by means of an electrostatic powder gun and the application of heat treatment to initiate fusion of the powder.

9.2.3.4 QUALITY OF COATING

9.2.3.4.1 Finish

The fully cured coating shall have a uniform, smooth, gloss finish with proper adhesion.

9.2.3.4.2 Film Thickness

The Epoxy coating shall be evenly applied to the minimum final film thickness as specified in Tables 1 to 6 of SABS 1274 and shall be tested in accordance with paragraph 9.2.4.4.

9.2.3.4.3 Electrical Insulation Defects

All coated surfaces likely to be frequently wetted under normal service conditions shall show no electrical insulation defects when tested in accordance with paragraph 9.2.4.3.

9.2.3.4.4 Finishing Coat Colours

The finishing coat colours shall be as specified in the Project Specification in accordance with the Departmental Colour Code.

Colours shall be in accordance with SABS 1091.

Where not specified, the selection of final colours shall be approved by the Engineer.

9.2.4 TESTING

To be read in conjunction with paragraph 4.1, Quality Assurance.

Testing shall be done in accordance with SABS 1274, Section 6 to comply with the requirements of Tables 1 to 6, Section 3.

9.2.4.1 CONTRACTOR'S AND ENGINEER'S INSPECTIONS

Paragraphs 1.4 and 3.1 of DWS 2020 shall apply.

9.2.4.2 VISUAL INSPECTION

All surfaces shall be inspected visually and shall be free from tears, runs, sags, wrinkles, blisters, change in colour or gloss, orange peel, dirt, visible pinholes, dust or fluff occlusions or any other visible defects.

9.2.4.3 HOLIDAY INSPECTION (ELECTRICAL INSULATION DEFECTS INSPECTION)

100% of all coated surfaces shall be tested and there shall be no electrical insulation defects on any area inspected.

Inspection procedure shall ensure that sufficient moisture is present at all times.

For films exceeding 500 µm thickness, a high voltage, electrical insulation defects detector shall be used in accordance with SABS 1217.

9.2.4.4 FILM THICKNESS

(a) Measurements shall be taken in accordance with SABS ISO 2808.

(b) 100% of all coating thicknesses measured shall comply with the minimum requirements of the Project Specification.

(c) DFT in excess of the prescribed maxima shall not necessarily constitute reason for rejection if the paint film is demonstrated to be sound in all respects.

(f) The method used to measure DFT, and the significance of the readings for each particular project, shall be agreed upon by all parties prior to commencement of the work.

9.2.4.5 DEGREE OF CURE OF FUSION-BONDED MATERIALS

The degree of cure of fusion-bonded material shall be assessed by solvent wiping in accordance with the method given in SABS 1217 (methyl ethyl ketone resistance test for Epoxy materials).

9.2.5 DAMAGED COATINGS

No repairs of damaged coatings shall be accepted.

10 GALVANIZING

10.1 STANDARDS

Reference is made to the latest issues of the following Standard Specifications:

SABS ISO	14713	Protection against corrosion of iron and steel in structures - guidelines.
SABS EN	10240	Internal/external protective coatings for steel tubes.
SABS ISO	1461	Hot-dip galvanized coatings on fabricated iron and steel articles.
SABS Method	772	Profile of blast-cleaned steel surfaces for painting.
SABS ISO	2063	Metallic and other inorganic coatings – Thermal spraying.
SABS ISO	2808	Determination of film thickness.
SABS ISO	8501-1	Preparation of steel substrates before application of paints and related products – Visual assessment of surface cleanliness – Part 1: Rust grades and preparation grades of un-coated steel substrates and of steel substrates after removal of previous coatings.
SABS	0374-1	The suitability of hot-dip galvanized steel piping for the transportation of water.
SABS	1344	Medium duty solvent detergent.
ISO	752	Zinc ingots.
EN	1179	Zinc and zinc alloys – primary zinc
SABS ISO	9000	Model for quality assurance in production and installation.

10.2 MATERIAL

(a) The impurities in the molten zinc, as defined in ISO 752 and EN 1179, shall not exceed a total of 1,5%.

(b) Steel to be hot-dip galvanized shall be:

(i) For aesthetic appearance

- Aluminium-killed steel or
- Silicon-killed steel with a Silicon content not exceeding 0,04% and a Phosphorus content not exceeding 0,02%.

NOTE: Material certification shall be supplied.

(ii) For general corrosion protection

- Aluminium killed steel or
- Silicon killed steel with a Silicon content not exceeding 0,25% and a Phosphorus content not exceeding 0,02%.

(c) The condition of articles to be hot-dip galvanized shall comply with “Annexure C” of SABS ISO 1461.

(d) The condition of tubes to be hot-dip galvanized on a continuous line shall comply with “Annexure A” of SABS EN 10240.

10.3 APPLICATION

(a) Shall only be done by members of the Hot Dip Galvanizers Association of Southern Africa (HDGASA) in accordance with SABS ISO 9000.

(b) Shall be in accordance with SABS ISO 1461 and SABS EN 10240 for tubes.

10.4 TOLERANCES

10.4.1 STEEL SPECIALS

Shall be in accordance with clause 6 of SABS ISO 1461.

10.4.1.1 SURFACE

The surfaces shall be free from nodules, blisters, roughness and sharp points. Un-coated areas, flux residues, lumps and zinc ash shall not be permitted.

Notwithstanding Clause 6.1 of SABS ISO 1461, in the case of handrails etc. a high quality surface finish is required and a bright smooth surface shall be achieved. Only materials specified under paragraph 10.2 (b) (i) shall be utilised. Double dipping shall not be allowed.

10.4.1.2 THICKNESS

The thickness of hot-dip galvanizing shall comply with the requirements of the table below.

Minimum coating thicknesses on items that are not centrifuged.

ARTICLES AND ITS THICKNESS	HEAVY DUTY COATING	LIGHT DUTY COATING	
	Coating thickness µm (min)	Local coating thickness µm (min)	Mean coating thickness µm (min)
≥ 6 mm ≤ Steel	105	70	85
3,0 mm ≤ Steel < 6,0 mm	80	55	70
1,5 mm ≤ Steel < 3,0 mm	65	45	55
Steel < 1,5 mm	55	35	45
Castings ≥ 6,0 mm	105	70	80
Castings < 6,0 mm	-	60	70

Heavy duty coatings are required except in the following cases:

(a) Where a high surface finish is required.

(b) Where otherwise specified in the Project Specification.

10.4.2 STEEL TUBES

Shall be in accordance with clause 7 of SABS EN 10240.

10.4.2.1 SURFACE

The surface of the coating shall be continuous, smooth and free from flux residues.

10.4.2.2 THICKNESS

The thickness shall comply with the requirements of the coating quality A1, in accordance with clause 8, Table 1 of SABS EN 10240, as specified below.

Minimum local coating thickness requirements for coating quality A1.

Requirements	Coating quality A1
Minimum local coating thickness on the inside surface except at the weld bead	55 µm
Minimum local coating thickness on the inside surface at the weld bead	28 µm
Minimum local coating thickness on the outside surface	55 µm

10.4.2.3 ADHESION

The coating shall show no evidence of flaking or cracking when tested in accordance with clause 11.4 of SABS EN 10240.

10.4.2.4 COATING QUALITIES

(a) Coating qualities shall be A1 for water installations – see sub-clause 8.2 of SABS EN 10240.

(b) The surface of the coating on the inside shall be as smooth as can be achieved by steam blowing.

10.5 TESTING

10.5.1 STEEL ITEMS

To be read in conjunction with paragraph 4.1, Quality Assurance.

10.5.1.1 VISUAL EXAMINATION

Where a superior aesthetic appearance of hot-dip galvanizing is requested, a bright mirror surface finish shall be achieved by the galvanizer.

10.5.1.2 THICKNESS

Thicknesses shall be in accordance with paragraph 10.4.1.2 and shall be tested in accordance with sub-clause 6.2 of SABS ISO 1461.

10.5.2 STEEL TUBES

To be read in conjunction with paragraph 4.1, Quality Assurance.

10.5.2.1 VISUAL EXAMINATION

Where a superior aesthetic appearance of hot-dip galvanizing is requested, a bright mirror surface finish shall be achieved by the galvanizer.

10.5.2.2 THICKNESS

Shall be tested in accordance with sub-clause 11.3 of SABS EN 10240.

10.5.2.3 ADHESION

Shall be tested in accordance with sub-clause 11.4 of SABS EN 10240.

10.5.2.4 CHEMICAL ANALYSIS

Shall be tested in accordance with sub-clause 11.5 of SABS EN 10240.

10.6 REPAIR METHODS

10.6.1 STEEL ITEMS

The total un-coated areas for renovation by the galvanizer shall not exceed 0,5% of the total surface area of a component. Each un-coated area for renovation shall not exceed 400 mm². If un-coated areas are larger, the item containing such areas shall be re-galvanized.

The repair method shall be approved by the Corrosion Engineer before repairs are initiated.

Repairs shall be by zinc thermal spray in accordance with SABS ISO 2063 or three component zinc solvent free Epoxy repair system. The repair shall include removal of any scale, cleaning and any necessary pre-treatment to ensure adhesion – refer surface preparation Section 7.

The coating thickness on the renovated areas shall be a minimum of 30 µm more than the local coating thickness specified in paragraph 10.4.1.2 for the relevant hot-dip galvanized coating unless otherwise specified by the Corrosion Engineer. The coating on the renovated areas shall be capable of giving sacrificial protection to the steel to which it is applied.

10.6.2 STEEL TUBES

- Repairs shall not be allowed on internal surfaces of tubes. Tubes shall be re-galvanized.
- Repairs on external surfaces shall be in accordance with paragraph 10.6.1.

10.7 DUPLEX SYSTEM (HOT-DIP GALVANIZING + ORGANIC COATING)

10.7.1 SURFACE PREPARATION

10.7.1.1 SURFACE PASSIVATION

Items to be over-coated shall not be passivated.

10.7.1.2 CONTAMINANTS AND PHYSICAL FACTORS

The following contaminants shall be removed:

(a) Galvanizing residues and passivation products.

(b) Oil and grease.

(c) Perspiration and oil contamination from contact with hands.

(d) Dust and chemical contamination.

10.7.1.3 DEGREASING

Galvanized steel surfaces shall be degreased prior to coating, using either a water soluble solvent degreaser in accordance with SABS 1344 and the manufacturer's instructions, or a mild acid-detergent degreasing solution to be approved by the Corrosion Engineer.

10.7.1.4 SWEEP BLAST-CLEANING

Large areas shall be prepared by sweep-blasting with non-metallic abrasive in accordance with paragraph 7.3.6.3. Cracking, flaking, or any form of delamination of the zinc coating due to excessive blast-cleaning shall not be permitted. Removal of zinc by blast-cleaning shall not exceed 10 µm.

10.7.1.5 MECHANICAL CLEANING

Surfaces that can not be sweep-blasted shall be abraded manually or mechanically with abrasive paper grade 220 or non-metallic abrasive pads.

10.7.2. APPLICATION

Coatings shall be applied immediately after surface preparation in accordance with paragraph 8.4.5. All coating materials shall be applied strictly in accordance with the manufacturer's instructions.

In the case of nuts, bolts and other fasteners, care shall be taken to ensure that all edges are over-coated to the minimum specified thickness.

Only coatings approved by the Corrosion Engineer for application on hot-dip galvanized surfaces shall be used.

For additional protection under high humidity conditions and for colour coding Epoxy and Polyurethane coatings shall be applied to thicknesses specified in paragraph 5.

Epoxy primer may not be required if appropriate two pack Epoxy/ Re-coatable or pure Aliphatic Polyurethane is being used.

10.7.3. REPAIRS OF DUPLEX SYSTEM

To repair coatings damaged during transportation, handling or erection, the following procedures shall be followed:

10.7.3.1 DAMAGE DOWN TO BARE STEEL

(a) Degrease in accordance with paragraph 7.3.3.

(b) Thoroughly abrade the damaged area, including an adjacent surrounding area of at least 25 mm wide, with grade 80 abrasive paper.

(c) Vacuum-clean the surface to remove dust and debris in accordance with SABS method 769 and paragraph 7.4.1.

(d) Where originally over-coated with two component Epoxies, wipe the surface with methyl ethyl ketone and allow to dry.

(e) Apply sufficient coats of three component zinc solvent free Epoxy to a dry film thickness of 30 µm more than the original thickness of the zinc.

(f) When dry, apply the same system as originally applied so as to cover the damaged area extending for 25 mm over the surrounding area.

NOTE:
1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.
2. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

10.7.3.2 DAMAGE DOWN TO ZINC SURFACE

(a) Prepare the surface as described in paragraph 10.7.3.1 - (a), (b) (c) and (d).

(b) Apply coating as described in paragraph 10.7.3.1 – (e) and (f).

NOTE: 1. When solvent borne materials are used, curing time between coats, as specified by the coating material manufacturer, shall be adhered to.

2. Apply a final top coat over the repaired area to achieve a pleasing, uniform finish of the item.

ANNEXURE C8

REQUIREMENTS TO BE SPECIFIED

A: INFORMATION TO BE SUPPLIED IN TENDER SPECIFICATION

ITEM	INSTRUCTION	PARAGRAPH
Corrosion protection system	Agreement and approval	3.1a
	Dry film thickness	8.4.3
Finishing coat colours	Departmental colour code	8.4.5.6.4 9.1.3.4.4 9.2.3.4.4
Repair kit	Required or not	9.1.6
Material type	Type of powder	9.2.2
Medium duty hot-dip galvanized coating	Medium duty	10.4.1.2

B: INFORMATION TO BE SUPPLIED BY TENDERER FOR ADJUDICATION

ITEM	INSTRUCTION	PARAGRAPH
Approval of specific corrosion systems	Approval	3.1 (b) 3.1 (c)
Proprietary items	Corrosion protection	5.1
Lifting lugs	Design	6.2.4
Blasting-material with data sheets	Blasting-material	7.6.6
Method of application	Epoxy	8.4.5.4.1
Coating for duplex system	Application of duplex system	10.7.2

C: INFORMATION TO BE SUPPLIED AFTER AWARD OF CONTRACT

ITEM	INSTRUCTION	PARAGRAPH
Quality plan	Approval	4.1.1
Suitability of design	Hot-dip galvanizing	6.4.2.2
Programme	Approval	7.3.1

ANNEXURE C8

DEPARTMENTAL COLOUR CODE

MECHANICAL AND GENERAL

ITEMS	COLOUR	SABS 1091 CODE
Structural steel, Gates	Light grey	G29
Hydraulic power pack	Strong blue	F11
Hydraulic oil	Salmon pink	A40
Hazardous objects/areas (restricted headroom, crane hook etc)	Golden yellow with black chevron	B49*
Handwheels and levers	Golden yellow	B49
Handrails: - vertical - horizontal	Black Golden yellow	 G49
Handrails on dam walls - Aluminium - Stainless steel - Galvanized	Un-coated Un-coated Light grey	 G29
Floors: - safe and walking areas - restricted areas - open flooring (gratings) – MS galvanized 3CR12 Stainless steel	Emerald green Golden yellow Un-coated Un-coated Un-coated	E14 B49*
Fire protection equipment	Signal red	A11*
Control panels	Eau de nil	H43

PUMP STATION

ITEMS	COLOUR	SABS 1091 CODE
Electric motors	Light beige	C57
Pumps/control valves: for raw water for chem-treated water	Apple green Middle blue	H29 F07
Fan and coupling guards	Signal red	A11*
Base plates	Black	
Overhead travelling cranes	Golden yellow	B49
Isolating valves: for raw water for chem-treated water	Brilliant green Arctic blue	H10 F28

ELECTRICAL

ITEMS	COLOUR	SABS 1091 CODE
Low voltage panels: indoor outdoor	Light orange Light orange	B26* B26
Medium voltage panels: indoor outdoor	Admiral grey Admiral grey	G12 G12
Panel accessories (gland plates, back plates, interior)	White	
UPS equipment	Light orange	B26
Transformers	Light stone	C37
LV distribution kiosks, mini subs	Light stone	C37
Standby electrical equipment (Permanently powered)	Signal red	A11*
General outdoor	Light grey green	H40
All equipment – interior	White	

WATER TREATMENT PLANT

ITEMS	COLOUR	SABS 1091 CODE
Equipment	Same colour of respective pipe work	
Handwheels (remote valves)	Same colour of respective pipe work	
PIPE WORK		
Raw water	Brilliant green	H10
Chemical treated raw water	Verdigris green	E22
Clarified raw water	Eau de nil	H43
Filtered water	Pale blue	E39
Chlorinated filtered water	Arctic blue	F28
Backwash water	Cornflower blue	F29
Air saturated water	Turquoise blue	E18
Wash water recovery	Middle buff	B33

SEWAGE PIPE WORK

ITEMS	COLOUR	SABS 1091 CODE
Raw sewage	Dark earth	B11
Settled sewage effluent	Brilliant green	H10
Biologically treated sewage effluent	Verdigris green	E22
Final/chlorinated effluent	Eau de nil	H43
Digested sewage sludge	Middle brown	B07
Raw sewage sludge	Dark brown	B03
Humus sludge	Golden brown	B13
Return activated sludge	Golden brown	B13
Waste activated sludge	Middle brown	B15
Supernatants/underflows returning to head of works	Middle buff	B33

DOSING/CONTROL PIPE WORK

ITEMS	COLOUR	SABS 1091 CODE
Poly-electrolite	Pinotage	A08
Alum/Ferric chloride	Jacaranda	F18
Chlorine solution	Primrose	C67
Chlorine gas	Lemon	C54
Chlorine liquid	Light orange	B26
Lime slurry	Biscuit	B64
Lime hydrated	Biscuit	B64
Lime saturated water	Biscuit	B64
Air/compressed air	White	
Steam	Pastel grey	G54

NOTE: Colours marked thus * are restricted for specified equipment only.

PART C3.4: AMENDMENTS TO THE STANDARD SPECIFICATIONS

C3.4: AMENDMENTS TO THE STANDARD SPECIFICATIONS

In certain clauses the standard and particular specifications allow a choice to be specified in the project specifications between alternative materials or methods of construction and for additional requirements to be specified to suit a particular contract. Details of such alternative or additional requirements applicable to this contract are contained in this part of the specifications. It also contains additional specifications required for this particular Contract.

The Amendments to the Standard Specifications are included as stand-alone sections, each with index pages that reference the relevant Standard Specification being amended. The paragraph and sub-paragraph numbers of each amendment are unique to the Standard Specification at hand. Each paragraph and sub-paragraph is immediately followed by the heading and the number of the clause or sub-clause in the Standard Specification being referenced.

New clauses and sub-clauses, which do not form part of a clause or sub-clause in the Standard Specifications are also included. The paragraph and sub-paragraph numbers of each of the new clauses and sub-clauses are also unique to the Standard Specification at hand. New clauses and sub-clauses are identified by the text ''NEW'' in their headings. Each paragraph and sub-paragraph which references a new clause or sub-clause is immediately followed by its heading containing the new clause or sub-clause number.

TABLE OF CONTENTS

Page

PSA 1 SCOPE

No amendments.

PSA 2 INTERPRETATIONS

PSA 2.2 APPLICABLE EDITION AND STANDARDS

Add at the beginning of Subclause 2.2:

"Unless a specific edition is specified (see the List of Applicable Specifications), ..."

PSA 2.4 ABBREVIATIONS

The terms “Schedule of Quantities” and “Bill of Quantities” shall be synonymous.

Except for references to the Bureau itself, or to the (official) SABS mark, the term “SABS” shall mean “SANS”.

Add to Subclause 2.4(b):

"MAMDD: Modified AASHTO maximum dry density.

TMH1: Technical Methods for Highways 1”.

PSA 2.8 ITEMS IN SCHEDULE OF QUANTITIES

PSA 2.8.1 Principle

In the fourth line of Subclause 2.8.1 of SANS 1200 A, after the word "specification", *add:* "or in the measurement and payment clause of the standard specification, particular specification, project specification or any amendments thereto".

Add the following paragraphs:

"The Contractor shall be deemed to have inspected and examined the Site and its surroundings and information available in connection therewith and to have satisfied himself before submitting his tender (as far as is practicable) as to

(a) the form and nature of the Site and its surroundings, including subsurface conditions,

(b) the hydrological and climatic conditions,

(c) the extent and nature of work and materials necessary for the execution and completion of the Works,

(d) the means of access to the Site and the accommodation he may require

and, in general, shall be deemed to have obtained all information (as far as is practicable) as to risks, contingencies and all other circumstances which may influence or affect his tender.

The Contractor shall be deemed to have based his tender on the technical data given in the Documents and, if in the performance of the Contract any circumstances shall differ from the said technical data, which difference causes delay or additional Cost, the Contractor shall be entitled to make a claim in accordance with Clause 10.1 of GCC2015.

The Contractor shall be deemed to have satisfied himself before tendering as to the correctness and sufficiency of his tender for the Works and of the rates and prices stated in the priced Bill of Quantities and the Schedule of Rates and Prices (if any) or in the specification, which rates and prices shall (except in so far as otherwise provided in the Contract) collectively cover full payment for the discharge of all his obligations under the Contract and all matters and things necessary for the proper completion of the Works."

PSA 3 MATERIALS

PSA 3.1 QUALITY

Add to the subclause:

"No used or recycled material may be used in the Works unless expressly authorised by the Engineer.

Where a material to be used in this Contract is specified to comply with the requirements of an SANS Standard Specification, and such material is available with the official SABS mark, the material used shall bear the official mark.

Samples of concrete aggregates are to be delivered to an approved laboratory.

Where proprietary products are specified, the Contactor may propose equal alternatives for approval by the Engineer. Alternative materials or equipment proposed by the Contractor shall be tested. The test, as well as the materials or equipment, shall be approved by the Engineer prior to any such materials or equipment being built into the works and all costs involved in testing shall be deemed to be included in the rates tendered."

Add the following new subclause to Clause 3:

PSA 3.3 ORDERING OF MATERIALS

The quantities set out in the Bill of Quantities have been carefully determined from calculations based on data available at the time of its compilation but are to be considered as approximate quantities only. Before ordering materials of any kind the Contractor shall be solely responsible for determining, from the drawings issued or approved by the Engineer for construction purposes, the actual quantities of materials required for the execution of the Works. No liability or responsibility whatsoever shall be attached to the Employer or the Engineer in respect of materials ordered by the Contractor except when ordered in accordance with the drawings issued or approved by the Engineer for construction purpose.

PSA 4 PLANT

PSA 4.1 SILENCING OF PLANT

Delete "in built up areas" in the second sentence and replace with:

"… in all areas within audible distance of residents (albeit urban, peri-urban or rural areas),…".

PSA 4.2 CONTRACTOR'S OFFICES, STORES AND SERVICES

Add to the subclause:

"Neither housing nor shelters are available for the Contractor's Employees, and the Contractor shall make his own arrangements to house his Employees and transport them to the site, no personnel may reside on the Site.

No water may be abstracted from water bodies for the purposes of construction without the approval of the Engineer.

The Contractor's camp shall be kept neat and clean at all times and all surplus or rejected material shall be removed from the site."

Add the following subclauses to Subclause 4.2:

"PSA 4.2.1 Medical facilities and safety equipment

The first aid services required in terms of Subclause 4.2 of SANS 1200 A shall include, inter alia, a First Aid cabinet fully equipped and maintained with at least the minimum contents as listed in the Annexure (Regulation 3) to the General Safety Regulations of the Occupational Health and Safety Act, 1993 (Act 85 of 1993), to deal with accidents and ailments which are likely to occur during the construction period.

The Contractor shall provide personal safety equipment and facilities as required by Regulation 2 of the General Safety Regulations of the Occupational Health and Safety Act, 1993 (Act 85 of 1993).

PSA 4.2.2 Latrine facilities

The Contractor shall provide and maintain on the Site adequate and suitable sanitary and first aid services and a supply of potable water for his employees engaged on the Contract and, if necessary, suitable accommodation and similar facilities elsewhere for such employees off the Site.

The suitable sanitary services shall be of the chemical type and shall be readily accessible to workers at all areas of the site.

The Contractor shall make all the necessary arrangements with the relevant local authority, or a commercial organisation approved by the local authority, for the disposal of the contents of the toilets on a regular basis."

PSA 5 CONSTRUCTION

PSA 5.1 SURVEY

PSA 5.1.1 Setting out of the Works

Add to the subclause:

"Before commencing any construction, the Contractor shall check the relative positions and levels of all reference pegs, bench marks and line pegs and inform the Engineer of any discrepancy.

The Contractor shall be responsible for the true and proper setting out of the Works and for the correctness of the position, levels, dimensions and alignment of all parts of the Works and for the provisions of all necessary instruments, appliances and labour in connection therewith. A centreline survey, at 10 m intervals, shall be carried out by the Contractor as part of the setting out of the Works. The survey data (X, Y, Z coordinates in format acceptable to the Engineer) shall be submitted to the Engineer, who shall be afforded at least 21 days to verify the surveyed ground profile against the vertical pipeline alignments and to make changes to the construction drawings where required. Allowance shall be made in the construction programme for this verification process.

The Contractor shall carefully protect and preserve all benchmarks, sight-rails, pegs and other things used in setting out the Works. For any new work the Contractor shall establish his own reference points from which the work can be set out.

The checking of any setting-out or of any line or level by the Engineer shall not relieve the Contractor of his responsibility for the correctness thereof.

If at any time during the progress of the Works, any error shall appear or arise in the position, levels, dimensions or alignment of any part of the Works, the Contractor, on being required to do so by the Engineer, shall at his own expense rectify such error to the satisfaction of the Engineer, but if such error is based on incorrect data supplied in writing by the Engineer or if there is any delay in providing the particulars required, the Contractor shall, in respect of that delay and the cost of such rectification, be entitled to make a claim in accordance with Clause 10 of GCC 2015."

Add the following new subclauses to Subclauses 5.1:

“**PSA 5.1.3 As-built survey**

The Contractor shall supply the Engineer with as-built survey data for the entire Works (including invert and cover levels, coordinates of manholes and points of intersection, valve chambers, etc). The Completion Certificate will not be issued until the as-built survey information had been approved by the Engineer.

PSA 5.1.4 Marker posts

The Contractor shall supply and accurately place marker posts on the centreline of the buried pipelines, or as instructed by the Engineer. Marker posts shall be placed at all points of intersection, chambers and at a maximum spacing of 250 m. Marker posts shall be placed only once the pipeline, or any section thereof, has been successfully tested.

The co-ordinates, level and centreline distance (as determined from the as-built survey and drawings) of each marker post shall be accurately determined and recorded by the Contractor. All details shall be given to the Engineer in writing.”

PSA 5.2 SAFEGUARDING AND ACCOMMODATION OF TRAFFIC

With reference to Subclause 5.2 of SANS 1200 A the Contractor shall, in addition to the requirements of Subclause 5.1.6 of SANS 1200 D and the Amendments thereto, carry out and maintain such temporary works and provide all temporary road signs, as are necessary to maintain and safeguard the normal flow of public and private, vehicular and pedestrian traffic.

All temporary signs shall be of the type and size required for rural roads, as applicable, as specified in the “Southern African Development Community Road Traffic Signs Manual and Chapter 13, [*Roadwork Signing*] of the South African Road Traffic Signs Manual”.

Unless the closing of streets, accesses and thoroughfares has been properly arranged, the Contractor shall accommodate and provide for through traffic, traffic at crossings and vehicular access to houses and buildings at all times. If necessary, safe ramps to mount road kerbs shall be provided where traffic is to be diverted.

In the case of crossing of a main road, the Contractor shall so arrange his work that only half of the roadway is closed to traffic at any one stage during normal working hours. Outside of normal working hours both lanes of the roadway shall be open to traffic.

Should the Contractor wish to provide temporary bypasses for the deviation of traffic, these shall consist of a minimum of 100 mm of gravel wearing course on selected fill. The Contractor shall maintain the wearing course to the satisfaction of the Engineer for the full time that the bypass is in use.

PSA 5.4 PROTECTION OF OVERHEAD AND UNDERGROUND SERVICES

Replace the heading and the contents of Subclause 5.4 with the following:

"PSA 5.4 LOCATION AND PROTECTION OF EXISTING SERVICES

PSA 5.4.1 Location of existing services

Before commencing with any work in an area, the Contractor shall ascertain the presence and actual position of all services which can reasonably be expected by an experienced and competent contractor to be present on, under, over or within the Site.

Without in any way limiting his liability in terms of the Conditions of Contract in relation to damage to property and interference with services, the Contractor shall, in collaboration with the Engineer, obtain the most up-to-date plans as are available, showing the positions of services existing in the area where he intends to work. Neither the Employer nor the Engineer offers any warranty as to the accuracy or completeness of such plans and because services can often not be reliably located from plans, the Contractor shall ascertain the actual location of services depicted on such plans by means of careful inspection of the Site.

Thereafter, the Contractor shall, by the use of appropriate methodologies, carefully expose the services at such positions as are agreed to by the Engineer, for the purposes of verifying the exact location and position of the services. Where the exposure of existing services involves excavation to expose underground services, the further requirements of subclauses 4.4 and 5.1.2.2 of SABS 1200 D (as amended) shall apply.

The aforesaid procedure shall also be followed in respect of services not shown on the plans but which may reasonably be anticipated by an experienced Contractor to be present or potentially present on the site.

All services, the positions of which have been determined as aforesaid at the critical points, shall henceforth be designated as 'known services' and their positions shall be indicated by the Contractor on a separate set of drawings, a copy of which shall be furnished to the Engineer without delay.

As soon as any service which has not been identified and located as described above is encountered on, under, over or within the site, it shall henceforth be deemed to be a known service and the aforesaid provisions pertaining to locating, verifying and recording its position on the balance of the site shall apply. The Contractor shall notify the Engineer immediately when any such service is encountered or discovered on the Site.

Whilst he is in possession of the Site, the Contractor shall be liable for all loss of or damage as may occur to

(a) known services, anywhere along the entire lengths of their routes, as may reasonably be deduced from the actual locations at which their positions were verified as aforesaid, due cognizance being taken of such deviations in line and level which may reasonably be anticipated, and

(b) any other service which ought reasonably to have been a known service in accordance with the provisions of this clause.

The Contractor shall also be liable for consequential damage in regard to (a) and (b), whether caused directly by the Contractor's operations or by the lack of proper protection.

No separate payment will be made to the Contractor in respect of his costs of providing, holding available on the Site and utilising the said detecting and testing equipment, nor for any costs incurred in preparing and submitting to the Engineer the Drawings as aforesaid. These costs shall be deemed included in the Contractor's other tendered rates and prices included in the Contract.

Payment to the Contractor in respect of exposing services at the positions agreed by the Engineer and as described above will be made under the payment items (if any) as may be provided for in the respective sections of the specifications pertaining to the type of work involved.

PSA 5.4.2 Protection during construction

The Contractor shall take all reasonable precautions and arrange its operations in such a manner as to prevent damage occurring to all known services during the period which the Contractor has occupation and/or possession of the Site.

Services left exposed shall be suitably protected from damage and in such a manner as will eliminate any danger arising therefrom to the public and/or workmen, all in accordance with the requirements of the prevailing legislation and related regulations.

Unless otherwise instructed by the Engineer, no services shall be left exposed after its exact position has been determined and all excavations carried out for the purpose of exposing underground services shall be promptly backfilled and compacted. In roadways, the requirements of subclause 5.9 of SABS 1200 DB should be observed. In other areas compaction is to be to 90% modified AASHTO density.

PSA 5.4.3 Alterations and repairs to existing services

Unless the contrary is clearly specified in the Contract or ordered by the Engineer, the Contractor shall not carry out alterations to existing services. When any such alterations become necessary, the Contractor shall promptly inform the Engineer, who will either make arrangements for such work to be executed by the owner of the service, or instruct the Contractor to make such arrangements himself.

Should damage occur to any existing services, the Contractor shall immediately inform the Engineer, or when this is not possible, the relevant authority, and obtain instructions as to who should carry out repairs. In urgent cases, the Contractor shall take appropriate steps to minimise damage to and interruption of the service. No repairs of telecommunication cables or electric power lines and cables shall be attempted by the Contractor.

PSA 5.7 SAFETY

Replace the contents of Subclause 5.7 with the following:

"Pursuant to the provisions of the Conditions of Contract, and without in any way limiting the Contractor's obligations thereunder, the Contractor shall at his own expense (except only where specific provision (if any) is made in the Contract for the reimbursement to the Contractor in respect of particular items), provide the following:

(a) Provide to its Employees on the site of the works, all safety materials, clothing and equipment necessary to ensure full compliance with the provisions of the Occupational Health and Safety Act, 1993 (Act No 85 of 1993) as amended (hereinafter referred to as the Act) at all times, and shall institute appropriate and effective measures to ensure the proper usage of such safety materials, clothing and equipment at all times;

(b) Provide, install and maintain all barricades, safety signage and other measures to ensure the safety of workmen and all persons in, on and around the site, as well as the general public;

(c) Implement on the site of the works, such procedures and systems and keep all records as may be required to ensure compliance with the requirements of the Act at all times;

(d) Implement all necessary measures so as to ensure compliance with the Act by all subcontractors engaged by the Contractor and their employees engaged on the works;

(e) Full compliance with all other requirements pertaining to safety as may be specified in the Contract.

The Employer and the Engineer shall be entitled, although not obliged, to make such inspections on the site as they shall deem appropriate, for the purpose of verifying the Contractor's compliance with the requirements of the Act. For this purpose, the Contractor shall grant full access to the site of all parts of the site and shall co-operate fully in such inspections and shall make available for inspection all such documents and records as the Employer's and/or Engineer's representative may reasonably require.

Where any such investigations reveal, or where it comes to the Engineer's attention that the Contractor is in any way in breach of the requirements of the Act or is failing to comply with the provisions of this clause, the Engineer shall, in accordance with the provisions of Clause 5.11 of GCC2015, be entitled to suspend progress on the works or any part thereof until such time as the Contractor has demonstrated to the satisfaction of the Engineer, that such breach has been rectified.

The Contractor shall have no grounds for a claim against the Employer for extension of time and/or additional costs if the progress on the works or any part thereof is suspended by the Engineer in terms of this clause, and the Contractor shall remain fully liable in respect of the payment of penalties for late completion in accordance with the provisions of Clause 5.13.1 of GCC2015 should the Contractor fail to complete the Works on or before the specified due completion date in consequence of the suspension.

Persistent and repeated breach by the Contractor of the requirements of the Act and/or this clause shall constitute grounds for the Engineer to act in terms of Clause 9.2.1.3.6 of GCC 2015 and for the Employer to cancel the Contract in accordance with the further provisions of the said Clause 9.2 of GCC 2015."

PSA 5.8 GROUND AND ACCESS TO WORKS

Add to the subclause:

"The Contractor shall, during construction of the Works:

a) improve and maintain to a standard that will ensure the safe execution of the Works, any existing access roads or roads built under this Contract and tracks required by him for the Works,

b) construct and maintain additional roads as necessary for his purposes to and along the working width of the pipeline route, to a standard required for the efficient construction of the Works.

c) keep all roads and access tracks used by him watered to minimise dust. The frequency of the watering shall be at least daily when roads and tracks are used by the Contractor, unless it is sufficiently damp after rain.

The Contractor shall not operate outside the "working width" or construction area as defined on the drawings, and he will be held wholly responsible for any damage or nuisance caused by himself, his plant, vehicles or staff throughout the period of the Contract.

Immediately on completion of each section of the Works, the Contractor shall:

a) reinstate all private roads used by him, other than those under (b) below, to at least their original condition,

b) scarify all roads constructed by him for construction purposes and which are not required by the property owner or the Employer,

On completion of operations the Contractor shall restore the ground surface, wherever it may have been disturbed, to its original condition by filling in all ruts with material similar to the material within the rut and levelling the ground and, where necessary, planting grass and shrubs as may be required. Any boundary fences which have been removed or damaged by his operations and activities shall be repaired and/or reinstated at the Contractor's expense. Ground restoration must include proper placement of topsoil profile."

Add the following new subclause to Clause 5:

"PSA 5.9 DRAWINGS AND DETAILS

Tender drawings shall not be used for construction purposes. Construction drawings and additional detailed information will be made available to the Contractor as and when required by him.

The originals of all Drawings and Specifications prepared by or on behalf of the Engineer shall remain in his custody and references herein to delivery to the Contractor of Drawings or specifications shall relate to true copies thereof.

The Contractor shall be entitled to receive free of charge, to the extent provided in the Contract, copies of each such Drawing and specification and to receive, at the cost of reproduction, such additional copies as he shall reasonably require.

One copy of all documents constituting the Contract shall be kept on the Site and be available for perusal by the Engineer or any person authorised by him.

The Contractor shall, in accordance with the Engineer's instructions, maintain a register on the Site of all Drawings and revisions thereof in the chronological order in which they are delivered to him.

PSA 5.10 SITE MEETINGS

The Contractor or his authorised agent will be required to attend regular site meetings, which shall normally be held once a month on dates and at times determined by the Engineer, but in any case whenever reasonably required by the Engineer. Unless otherwise indicated in the Contract or instructed by the Engineer, such meetings shall be held at the Contractor's offices on the site. At such monthly meetings, matters such as general progress on the works, quality of work, problems, claims, payments, and safety shall be discussed, but not matters concerning the day-to-day running of the Contract.

PSA 6 TOLERANCES

PSA 6.2 DEGREES OF ACCURACY

Add to the subclause:

"Generally, Degree of Accuracy II shall be applicable to the whole of the Works, unless specified otherwise (refer specifically to Amendments to SANS 1200 D and Particular Specification DWS 0750)."

Add the following subclause to Clause 6:

"PSA 6.4 USE OF TOLERANCES

No guarantee is given that the full specified tolerances will be available independently of each other, and the Contractor is cautioned that the liberal or full use of any one or more of the tolerances may deprive him of the full or any use of tolerances relating to other aspects of the work.

Except where the contrary is specified, or when clearly not applicable, all quantities for measurement and payment shall be determined from the 'authorised' dimensions. These are specified dimensions or those shown on the Drawings or, if changed, as finally prescribed by the Engineer, without any allowance for the specified tolerances. Except if otherwise specified, all measurements for determining quantities for payment will be based on the 'authorised' dimensions.

If the work is constructed in accordance with the 'authorised' dimensions plus or minus the tolerances allowed, the calculation of quantities will be based on the 'authorised' dimensions, regardless of the actual dimensions to which the work has been constructed.

When the work is not constructed in accordance with the 'authorised' dimensions plus or minus the tolerances allowed, the Engineer may nevertheless, at his sole discretion, accept the work for payment. In such cases no payment shall be made for quantities of work or material in excess of those calculated for the 'authorised' dimensions, and where the actual dimensions are less than the 'authorised' dimensions minus the tolerance allowed, quantities for payment shall be calculated based on the actual dimensions as constructed."

PSA 7 TESTING

PSA 7.2 APPROVED LABORATORIES

Replace the contents of Subclause 7.2 with the following:

"Unless otherwise specified in the relevant specification or elsewhere in the Project Specification, the following shall be deemed to be approved laboratories in which design work, or testing required in terms of a specification for the purposes of acceptance by the Engineer of the quality of materials used and/or workmanship achieved, may be carried out:

a) Any testing laboratory certified by the South African National Accreditation Systems (SANAS) in respect of the nature and type of testing to be undertaken for the purposes of the Contract;

b) Any testing laboratory owned, managed or operated by the Employer or the Engineer;

c) Any testing laboratory established and operated on the Site by or on behalf of the Employer or the Engineer.

d) Any other laboratory that the Engineer approves in his absolute discretion."

PSA 8 MEASUREMENT AND PAYMENT

PSA 8.2 PAYMENT

PSA 8.2.2 Time-related items

Amend the third and fourth lines to read:

“incremental amounts (calculated by the division of the remainder of the tendered sum by the number of remaining months of the duration of construction as assessed by the Engineer) will be”

Add to the subclause:

“Notwithstanding the provisions of Sub Clause 8.2.2 of SANS 1200 A, an approved extension of time will not qualify the Contractor to receive any payment for that portion of fixed charge and value-related items which has become regarded as "time-related" items in terms of Subclause 8.1.1 and Subclause 8.2.2 of SANS 1200 A, above.”

PSA 8.3 SCHEDULED FIXED-CHARGE AND VALUE-RELATED ITEMS

PSA 8.3.2 Establishment of facilities on the site

PSA 8.3.2.1 Facilities for the Engineer

Add the following additional subitems:

“(d) Carports (3 No.) ....Unit : Sum

(e) Survey equipment..Unit : Sum

The tendered rate shall cover all costs as specified in Sub Clause 8.3.2.3 of SABS 1200 A (and Clauses 3.2 and 4.4 of the Amendments to SANS 1200 AB, if applicable), as well as maintaining all facilities."

PSA 8.3.2.2 Facilities for Contractor

Facilities for the Contractor will not be measured and paid for separately as itemized in Subclause 8.3.2.2 of SANS 1200 A. The sub-items (a) to (j) are to be consolidated into one item and payment under this Item (PSA 8.3.2.2) shall be deemed to cover all these sub-items as well as maintaining all facilities.

PSA 8.3.4 Removal of site establishment

The tendered rate for the removal of the Site establishment, in addition to Sub clause 8.3.4 of SANS 1200 A, shall cover the cost of the work specified in Sub clause 5.6 above and the cost of complying with Clause 5.15 of the General Conditions of Contract 2015.

The fencing of the Contractor's site will be held to have been covered by the tendered rates for the establishment and removal of site facilities.

PSA 8.4 SCHEDULED TIME-RELATED ITEMS

PSA 8.4.2 Operation and maintenance of facilities on Site

PSA 8.4.2.1 Facilities for Engineer

Add the following additional subitems:

"(e) Carports ....……..………………………………Unit : Sum

(f) Survey equipment...............................……..…………………………………Unit : Sum

The tendered rates shall cover all costs as specified in Subclause 8.4.2.3 of SANS 1200 A and 5.5 of SANS 1200 AB and as specified in Subclauses 3.2 and 4.4 of SANS 1200 AB."

PSA 8.4.2.2 Facilities for Contractor

Consolidate sub-items (a) to (j) of Clause 8.4.2.2 of SANS 1200 A into one item as in Subclause 8.2.1.2 above. Payment under this Item (PSA 8.4.2.2) shall be deemed to cover sub-items (a) to (j).

PSA 8.4.3 Supervision for duration of construction

Replace the words "general foreman, section foremen" *with* "salaried general and/or section foremen"

PSA 8.5 SUMS STATED PROVISIONALLY BY THE ENGINEER

Replace the contents of Subclause 8.5 with the following:

"**PSA 8.5.1 Works executed by the Contractor** ....Unit: Prov Sum

The Contractor will be reimbursed in substitution of the Provisional Sums (if any) allowed in the Schedule of Quantities for work to be executed by the Contractor, in the amounts determined in accordance with the provisions of Clause 6.6 (GCC 2015).

PSA 8.5.2 Works executed by Nominated Subcontractors

(a) Work to be executed by a Nominated Subcontractor .... Unit: Prov Sum

(b) Overheads, charges and profit on item (a) above .... Unit: % or sum

Subitems (a) and (b) will be provided in the Bill of Quantities for each different Nominated Subcontract included in the Contract.

The Contractor shall be reimbursed under subitem (a), in substitution of the respective Provisional Sums (if any) allowed in the Schedule of Quantities, the amounts actually paid or payable by the Contractor to the respective Nominated Subcontractors, in accordance with the provisions of Clause 6.6 (GCC 2015).

The Contractor shall be paid under subitem (b), either:

(a) where the unit of measurement for subitem (b) was specified as being a percentage, the respective percentage, as stated by the Contractor in is tender, of the amount certified by the Engineer for payment under the related subitem (a), all in accordance with the provisions of Clause 6.6.1.2.1 (GCC 2015), or

(b) where the unit of measurement for subitem (b) was specified as being a lump sum, an amount which is in the same proportion to the amount certified for payment under subitem (a) and the tendered lump sum is to the amount of the Provisional Sum stated under subitem (a) in accordance with the provisions of Clause 6.6.1.2.2 (GCC 2015),

provided always that where the Contractor has failed for any reason to insert a percentage or sum (as applicable) for subitem (b) in its tender, or where no provision was made in the tender documents for tenderers to make any such entry, the Contractor will be paid an amount equal to SEVEN AND ONE HALF PER CENT (7,5%) of the amount actually certified by the Engineer for payment under subitem (a).

The percentage or sum (as applicable) paid under subitem (b) as aforesaid, shall be deemed to include for full and final compensation to the Contractor for all costs as may be incurred and all charges and profits associated with the engagement, supervision, administration and management of the Nominated Subcontractor required of him in fulfilling its obligations under the Contract as the Principal Contractor."

PSA 8.6 PRIME COST ITEMS

Replace Subclause 8.6 with the following:

"PSA 8.6 PRIME COST SUMS

(a) Description of item to which Prime Cost Sum applies .... Unit: PC Sum

(b) Charge required by Contractor on subitem (a) above .... Unit: %

Subitems (a) and (b) will be provided in the Schedule of Quantities for each different item to which a Prime Cost Sum applies.

The Contractor shall be reimbursed under subitem(s) (a) in substitution of the respective Prime Cost Sums included in the Contract, the actual price(s) paid or payable by him in respect of the goods, materials or services supplied, but excluding any charges for the Contractor's labour, profit, carriage, establishment or other charges related to such goods, services or materials.

The Contractor shall be paid under subitem (b), the respective percentage, as stated by the Contractor in his tender, of the amount certified by the Engineer for payment under the related subitem (a). The percentages tendered by the Contractor for each respective subitem (b) included in the Schedule of Quantities shall be deemed to be in full and final compensation to the Contractor in respect of any charge by the Contractor for labour, carriage profit, establishment and for any other charges related to the goods, services or materials supplied under the related subitem (a).

If the Contractor shall have omitted within his tender to insert a tendered percentage under subitem (b), or tendered a zero percentage, the Contractor's tendered rate for subitem (b) shall be deemed to be zero and the Contractor shall not be entitled to any payment under subitem (b).

Note in connection with additional tests required by the Engineer:

When a PC sum is included in the Schedule of Quantities for additional tests required by the Engineer, the Contractor shall be responsible for both the cost of normal testing as described in PSA 7.2 and for the cost of any additional test that indicates that the specifications have not been complied with."

PSA 8.7 DAYWORK

Provisional items for Daywork are scheduled as follows:

a) Labour at hourly rates for foreman, skilled, semi-skilled and unskilled labourers.

b) Material as a Provisional Sum with a percentage allowance on the net cost.

c) The Contractor's own plant.

Tendered unit rates or unit rates that are agreed in terms of Clause 6.5 of the General Conditions of Contract 2015 for the Contractor's own plant used for Daywork shall cover the full and final cost of the use of such plant and shall therefore, in addition to the items listed in Sub clause 8.7 of SANS 1200 A, cover the cost of plant operators, consumable stores, fuel and maintenance.

d) Hired plant as a Provisional Sum with a percentage allowance on the net cost.

The Contractor will be paid the actual net cost of plant hired by him for Daywork and in addition will be paid a percentage allowance on the net cost of such hire, which allowance will cover the Contractor's own overhead costs and profit.

Only the net working hours will be measured under Daywork and it will be held that the Contractor has made provision in his rates for possible interruptions and standing time.

PSA 8.8 TEMPORARY WORKS

PSA 8.8.1 Main access road to Works

The Contractor will be held to have satisfied himself with regard to the accessibility of the site and the standard of access available via the existing main roads, minor roads and tracks. The tendered sum shall cover the cost of the upgrading or constructing where necessary, and maintenance of existing access, including new access roads as required by the Contractor.

The cost of maintenance, watering as specified in PSA 5.8 and temporary repair of all existing access roads, new access roads required by the Contractor and tracks shall be included in the sum. The tendered sum shall cover the cost of all maintenance required to the standard specified throughout the construction period and the reinstatement/scarifying of the roads as specified in PSA 5.8 above.

PSA 8.8.2 Dealing with traffic

Dealing with traffic, the maintenance of access, protection at level crossings and other requirements of PSA 5.2 shall be covered by the respective item in Section A of the Bill of Quantities.

Replace Clause 8.8.4 with the following:

"PSA 8.8.4 Location and protection of existing services

Where particular items are provided in other sections of the bills the costs of detection, exposure, protection and alterations shall be covered by such particular items. Where no such particular items are provided and where there is reason to expect the presence of such a service or services, the following items will apply:

PSA 8.8.4.1 Provision of detecting devices for:

(i)	Water and sewer pipes	Unit : Sum
(ii)	Electrical and other cables	Unit : Sum
(iii)	Other	Unit : Sum

The tendered sums shall cover the cost of providing and operating suitable equipment for as long as is necessary in order to locate all existing services likely to be affected by the construction activities. Alternatively an approved specialist firm may be employed to carry out the work.

PSA 8.8.4.2 Hand excavation necessary for locating and exposing existing services in all materials:

(i)	In roadways	Unit : m^3
(ii)	In all other areas	Unit : m^3

The rates shall cover the cost of excavating by means of hand tools within authorised dimensions, for all precautionary measures necessary to protect the services from damage during excavation and backfilling and for subsequent backfilling and compacting. Compaction of material in all areas except in roadways shall be to 93% of modified AASHTO density.

The rate for hand excavation in roadways shall also include compensation for compacting excavated or selected backfill material to 100% of modified AASHTO density. Reinstating layerworks and surfacing shall be measured and paid for under SABS 1200 DB.

The tendered rates shall also include for keeping excavations safe, for dealing with surface and subsurface water and for removal of surplus excavated material from the site."

Add the following new subclauses to Subclause 8.8:

"PSA 8.8.7 Dealing with water

The sum shall cover the cost for the provision, operation, maintaining and removal of all plant and materials required to deal with any surface and ground water anywhere on the Site as required in terms of Subclause 5.1.3 of SABS 1200 D and Subclause 5.1.2 of SABS 1200 DB. No additional payment will be made for "Special water hazards".

The sum shall cover the cost of providing the necessary plant or materials, or both, fully erected and operative on the Site, the cost of operating and maintaining pumps, well points, sheeting, close timbering, and other equipment, as applicable, for 24 hours a day, 7 days a week, throughout the period during which the facilities are required, and the cost of removing such goods and restoring the Site to its original condition on completion of that part of the project for which the temporary works were erected.

PSA 8.8.8 Survey

PSA 8.8.8.1 Establish survey control points and bench marks

The cost of establishing survey control points and bench marks for the Works, and the maintaining thereof for the duration of the Contract, shall be measured under the respective item in Section A of the Bill of Quantities.

PSA 8.8.8.2 Setting out

The cost of setting out, including the cost of establishing temporary bench marks and pegs in terms of Subclause 5.2.1 above, will be held to be covered by the rates tendered for the other fixed charge and time-related items in Section A of the Bill of Quantities.

PSA 8.8.8.3 Survey beacons and boundary pegs

Any costs in connection with the replacement of beacons or pegs for which the Contractor is responsible in terms of Subclause 5.1.2 of SANS 1200 A will be recoverable from the Contractor by deduction from the monthly certificate of payment.

Add the following new subclauses to Clause 8:

"PSA 8.9 FREEHAUL AND OVERHAUL

All haulage will be considered to be freehaul and the cost thereof will be deemed to be covered by the rates for the provision or disposal of the applicable material and, notwithstanding any clauses in C3: Scope of Work dealing with the definition, measurement and/or payment for transport, freehaul and/or overhaul, no other measurement nor payment for overhaul will be made.

PSA 8.10 MISCELLANEOUS ITEMS

An item which, in the payment clause column of the Bill of Quantities, refers to this clause, will be measured in the unit scheduled.

The sum or rate for such item shall cover the cost of all materials, labour and plant required to execute and complete the work as specified, described in the Bill of Quantities or shown on the drawing(s).

PSA 8.11 PROVISION OF SECURITY PERSONNEL

The costs of whatever nature for providing security personnel the Contractor deems appropriate, taking cognisance of the location of the site, will be deemed to be covered by the sums tendered for the respective items in Section A of the Bill of Quantities.

PSA 8.12 HEALTH AND SAFETY

The costs of whatever nature for complying with the Occupational Health and Safety Act 1993, Construction Regulations 2014, the Occupational Health and Safety Specification, the provision of the Health and Safety Plan and the maintenance of the Health and Safety file will be deemed to be covered by the sums tendered for the respective items in Section A of the Bill of Quantities.

PSA 8.13 ENVIRONMENTAL MANAGEMENT

The costs of whatever nature for complying with the obligations of the Environmental Management Plan and specifications included under C3.3 Particular Specifications will be deemed to be covered by the sums tendered for the respective items in Section A of the Bill of Quantities.

PSA 8.14 QUALITY MANAGEMENT PLAN

The costs of whatever nature for providing the Quality Management Plan as specified in Part C3 will be deemed to be covered by the sums tendered for the respective items in Section A of the Bill of Quantities."

TABLE OF CONTENTS

PSAB 1 SCOPE

No amendments.

PSAB 2 INTERPRETATIONS

PSAB 2.3 DEFINITIONS

Delete the first two lines and substitute the following:

"For the purposes of this specification the definitions given in SABS 1200 A shall apply."

PSAB 3 MATERIALS

PSAB 3.1 NAMEBOARDS

Add to the subclause:

"The position of the name boards (two off) will be subject to the Engineer's approval and must in no way obstruct sight lines for road, rail or pedestrian traffic. The name boards shall conform to the standard layout and design as formulated by the Employer (drawing available from Engineer). All arrangements regarding permission and approval from the controlling authority as far as location are concerned are the Contractor's responsibility.

The wording for the name board shall be as ordered at the commencement of the Works."

PSAB 3.2 OFFICE BUILDING(S)

Delete the first sentence and replace with the following:

"The Contractor shall supply and furnish three air-conditioned and heated "Kwikjack" or similar approved (6m x 3m) offices for the use of the Engineer and his/her staff, and one air-conditioned "Kwikjack" or similar approved (9m x 3.4m) conference facility for conducting meetings. All windows in the office shall be fitted with blinds and burglar proofing over the entire glazed area, and with fly screens over the openings."

Add to the subclause:

"In addition to the furnishings listed under sub-items (a) to (j), the following shall be provided and properly maintained:

k) electrical installation to include a light and two 15A plug points plus two adequately sized air conditioning units (for heating and cooling) for each unit
l) one refrigerator of at least 100 litre capacity
m) one kettle of at least 2 litre capacity
n) one tea set comprising twelve cups and saucers, twelve teaspoons, two teapots, one sugar bowl and one milk jug
o) covered parking for three vehicles
p) un-covered parking space for eight vehicles
q) four "Barhold" or similar wall mounted racks each with 6 clamps suitable for hanging A0 sized drawings
r) one large meeting table to seat twelve people
s) sixteen additional chairs

t) One A0 sized drawing table
u) Rain gauge
v) Wifi router and additional antenna required to provide an internet connection of at least 10 Mb/s.

Add the following new subclause to Clause 3:

PSAB 3.3 PROTECTIVE CLOTHING

The Contractor shall provide and replace when necessary five sets of safety helmets, safety shoes and gumboots (of sizes as required) to members of the Engineer's site staff and their visitors.

PSAB 4 PLANT

PSAB 4.1 TELEPHONE

Delete subclause and substitute the following:-

"The Contractor shall, subject to availability from Telkom, arrange for the installation in the Engineer's office a telephone for the sole use of the Engineer or his Representative. In addition, three portable cellular (18 hours standby and 3 hours talk time) telephones shall be made available for the sole use by the Engineer or his Representative for the duration of the contract."

Add the following new subclauses to Clause 4:

"PSAB 4.2 PHOTOCOPYING MACHINE

The Contractor shall provide, maintain and service one photocopying machine, able to print and scan A4 & A3 sizes, in the Engineer's office together with an adequate supply of paper of A3 and A4 size. The photocopying machine shall be of the 3-in-1 type to perform scanning of documents.

PSAB 4.3 MEDICAL FACILITIES AND SAFETY EQUIPMENT

The Contractor shall make the first aid services and such personal safety equipment and facilities as are required in terms of Subclause 3.1.1 of the Amendments to SANS 1200 A, available to the Engineer and his site staff.

PSAB 4.4 SURVEY EQUIPMENT

The Contractor shall provide the following survey equipment on the site from the commencement to the completion of the works:

- One tachometer capable of reading to twenty seconds of arc plus tripod
- One automatic reading Engineer's level plus tripod
- One levelling staff (5m long, 1cm graduations)
- One staff angle bubble
- One metal change-point for levelling
- One separate plumb-bob
- One spirit level (one metre long)
- One hammer (2kg) with steel or wooden pegs as necessary
- Two canvas carry bags
- One 50m steel tape

- One 5,0m (or longer) retractable steel tape

The equipment may be shared by arrangement between the Contractor and the Engineer or his representative on Site. The Contractor shall keep the equipment continuously insured against any loss, damage, or breakage and he shall indemnify the Engineer and the Employer against any claims in this regard. Upon completion of the Works the survey equipment as listed above shall revert to the Contractor.

The Contractor shall maintain the equipment in good working order and keep it clean until the completion of the works.

PSAB4-5 VEHICLES FOR THE ENGINEER

The Contractor shall provide two covered 4 x 4 (4-wheel drive) light delivery vehicles for the duration of the period of construction and until one month after the issue of the Certificate of Completion for the exclusive use of the Engineer on Site and off Site for such trips as may be necessary for the supervision of the Contract, and for commuting of the Engineer's site staff to their place of residence.

The vehicles shall not have done more than 30 000 km at the beginning of the Contract.

The vehicles shall have a load capacity of at least 1 000 kg with an engine capacity of at least 2 000 cc. The vehicles shall have power steering and air conditioning. The vehicles shall be licensed and insured (comprehensive insurance – excess payments shall not exceed R 5 000 or 7,5% of the claimed damage per event) and shall carry all necessary statutory permits. The vehicles shall not carry any advertisement or logo. The vehicles shall remain the property of the Contractor who will be responsible for its maintenance including the provision of fuel and oil as necessary."

PSAB 5 CONSTRUCTION

PSAB 5.2 ENGINEER'S OFFICE

Add to the subclause:

"The toilet facilities provided for the sole use of the Engineer or his Representative(s) shall be of the chemical type, maintained in a hygienic and sanitary condition and shall be removed on completion of the works. The facilities provided shall conform to the local health authority requirements as applicable and the Contractor shall pay all sanitary feeds and charges."

PSAB 5.3 KEY PERSONNEL

The Contractor shall inform the Engineer of the person to whom he has assigned duties with respect to the Site in terms of the Occupational Health and Safety Act and the person(s) who are in possession of a valid certificate of competency in first aid. The Contractor shall give copies of the minutes of the monthly site safety meetings to the Engineer.

PSAB 5.4 TELEPHONE

Delete the last sentence.

PSAB 5.5 SURVEY ASSISTANTS

Delete the first sentence and substitute the following:

"The Contractor shall make available to the Engineer two suitably educated labourers for use on and about the site for survey and other work directed by the Engineer at all reasonable times."

Add the following new subclause to Clause 5:

"PSAB 5.6 SITE INSTRUCTION BOOK

Throughout the construction period the Contractor shall supply a carbon quadruplicate book as a site instruction book.

This book shall be kept on Site and shall be accessible to both the Contractor and the Engineer at all times. It shall be used:

a) by the Contractor for providing the Engineer with any information regarding the construction of the Works which may be requested, and giving notification in writing of inspections, drawings, etc, required by the Contractor, and

b) by the Engineer for the purpose of writing day-to-day instructions, issuing of construction drawings and confirming any verbal information or instructions given to the Contractor.

One copy of each site note issued shall remain in the book."

PSAB 6 TOLERANCES

No amendments.

PSAB 7 TESTING

No amendments.

PSAB 8 MEASUREMENT AND PAYMENT

PSAB 8.1 SCHEDULED ITEMS

Delete the 1st sentence and substitute the following:

"Items will be scheduled in terms of Sub-Clauses 8.3.2 & 8.4.2 of SANS1200 A."

PSAB 8.2 PAYMENT

PSAB 8.2.1 Fixed and time-related charges

Delete the 1st sentence and substitute the following:

"The terms of Subclause 8.2 of SANS 1200 A shall apply."

Add to the subclause:

"The Tenderer is to include, under the Time-Related Charges, a sum of R 2500,00 per week for a period of time equal to the Time for Completion of the Contract (see Contract Data) to cover the cost of the Engineer's telephone calls.

The cost of installation and usage of the photocopying machine will be deemed to be included in the sums tendered for in the specific items in Section A of the Bill of Quantities. The cost of maintenance and paper will be paid under a separate item."

TABLE OF CONTENTS

Page

PSC 1 SCOPE

No amendments.

PSC 2 INTERPRETATIONS

No amendments.

PSC 3 MATERIALS

PSC 3.1 DISPOSAL OF MATERIAL

Delete the whole of Subclause 3.1 and replace with:

“DISPOSAL OF MATERIAL. Material, that is not re-usable, obtained from clearing and grubbing and from the demolition of structures shall be disposed of at areas off site. The Contractor shall obtain his own dumping sites for the disposal of material and all transport costs shall be included in the rates tendered for site clearance.

Wood obtained from clearing and grubbing operations shall remain the property of the landowner or community and shall be stacked at points designated by the Engineer within the boundaries of the Site. All tree trunks and branches of diameter exceeding 50 mm shall be stripped of secondary branches, cut into lengths not exceeding 2400 mm, and stacked at the designated points.

Fencing wire shall be neatly wound into rolls or coils and all such wire, together with all re-usable material from structures, etc., shall be stacked at designated points. Brush wood (i.e. < 50mm diameter) shall be disposed of by spreading and burying it under excess excavated material as specified above.”

PSC 4 PLANT

No amendments.

PSC 5 CONSTRUCTION

PSC 5.1 AREAS TO BE CLEARED AND GRUBBED

Add the following:

"Only the approved minimum area required for the execution of the Works including areas on which material shall be stockpiled for later reuse or on which material shall be dumped and spread, shall be cleared and grubbed.

For the pipe trenches generally a sufficiently wide strip required for the execution of the works, including safe working space, stockpiling of backfill material, access, placement of pipes alongside the trench and stockpiling of topsoil material, shall be cleared of vegetation. The width cleared shall, however, not extend more than the working widths as indicated on the drawings.

Trees and shrubs can only be removed or trimmed with the approval of the Engineer. Route pegs or markers shall not be destroyed or damaged during clearing operations."

The following applies to other clearing widths:

a) The width to be cleared for roads shall not exceed 0,5 m beyond the road footprint, including the toe of fill and top of cut.

b) The area to be cleared for the Works and stock pile areas shall not exceed the specified dimensions by a margin of 0,5 m measured from the perimeter."

PSC 5.3 CLEARING

Add the following Subclause:

"Where the pipeline route crosses an existing fence, a section of fencing not exceeding 20,0m in length may be removed temporarily during construction and thereafter reinstated to a condition not worse than the original as soon as the pipeline has been installed and backfilled in the immediate vicinity of the crossing. For the period while the existing fence is dismantled, the Contractor shall erect, at the end of each day's operations, a temporary fence to close the gap in the existing fence.

The design, layout and materials to be used for the temporary fencing shall be subject to the Engineers approval before it is erected."

PSC 5.4 GRUBBING

Delete "200 mm" in the fourth line and replace with "300 mm".

PSC 5.5 RECLEARING OF VEGETATION

Add the following:

"When areas have to be re-cleared on the written instructions of the Engineer, such re-clearing shall be carried out at the Contractor's own cost and the Contractor is therefore advised not to clear the areas too soon."

PSC 5.6 CONSERVATION OF TOPSOIL

Add the following:

"Topsoil up to a depth of 150 mm, where shown on drawings or as directed by Engineer on site, shall be removed from the above specified cleared areas and stockpiled on approved sites for later reuse.

Until required for spreading, the stockpiles of topsoil material shall be stabilized by watering or other approved means."

PSC 6 TOLERANCES

No amendments.

PSC 7 TESTING

No amendments.

PSC 8 MEASUREMENT AND PAYMENT

PSC 8.1 BASIC PRINCIPLES

Add the following:

"Levels to be used for earthworks quantity calculations will be surveyed once the clearing and stripping of topsoil operation has been completed."

PSC 8.2 SCHEDULED ITEMS

PSC 8.2.1 Clear and grub

Replace the first line with the following:

"The area designated by the Engineer to be cleared and grubbed will be measured in square metre to the nearest square metre or, "

PSC 8.2.3 Dismantle, remove and reinstate pipelines, electricity transmission lines, cables, etc.

Replace the contents of this subclause with:

"The tendered rates shall include full compensation for the detection, disconnection, removal, stockpiling, safeguarding, reinstatement and reconnection of services, including all necessary excavation, bedding, concrete bases and backfilling.

In the event of the contractor damaging any of the services he will replace it at his own cost."

PSC 8.2.10 Removal topsoil to nominal depth of 150 mm and stockpile

Replace the contents of this subclause with:

"The removal and conservation of topsoil will be paid by area. The rate tendered for topsoil shall, in additional to the items listed in Subclause 8.2.10, also cover the cost of stabilizing and protecting the stockpiles of topsoil."

Add the following items in Subclause 8.2:

"PSC 8.2.11 Take down and re-erect existing fence..Unit : m

The rate shall cover the cost of taking down the fences, coiling wire, sorting, stacking and guarding all material, the cost of loading, transporting and off-loading such material, the cost of re-erecting the fence in its original position using the dismantled material and the cost of temporary bracing the sections of fence not taken down.

The rate shall also cover the cost of using new tying wire but not the cost of any other new material that may have to be used on the written instructions of the Engineer."

TABLE OF CONTENTS

Page

PSD 1 SCOPE

No amendments.

PSD 2 INTERPRETATIONS

PSD 2.1 SUPPORTING SPECIFICATIONS

Replace Subclause 2.1.2 with the following:

"Any of the other SANS 1200 specifications may form part of the Contract documents."

PSD 2.3 DEFINITIONS

Replace the word and the definition for "Borrow" *with the following:*

"**Borrow material**: Material, other than material obtained from excavations required for the works, obtained from sources such as borrow pits or the authorised widening of excavations. 'Borrow' shall have a corresponding meaning."

Replace the definition for "Specified density" *with the following:*

"**Specified density**: The specified dry density expressed as a percentage of modified AASHTO dry density."

Replace the definition for "Stockpile" *with the following:*

"**Stockpile** (verb): The process of selecting and, when necessary, loading, transporting and off-loading material in a designated area for later use for a specific purpose."

Add the following definitions:

"**Commercial source**: A source of material provided by the Contractor, not the Employer, and including any borrow pit, provided by the Contractor.

Fill: An embankment or terrace constructed of material obtained from excavations or borrow pits. In roads it includes the earthworks up to the underside of the selected subgrade level.

Fill (material): Material used for the construction of an embankment or terrace.

Roadbed: The natural in situ material on which the fill or, in the absence of fill, the pavement layers are constructed."

PSD 3 MATERIALS

PSD 3.1 CLASSIFICATION FOR EXCAVATION PURPOSES

PSD 3.1.1 Method of classifying

Add the following:

"The classification of material other than 'soft excavation' shall be agreed upon before excavation may commence.

The Contractor shall immediately inform the Engineer if and when the nature of the material being excavated changes to such an extent that a new classification is warranted for further excavation. Failure on the part of the Contractor to advise the Engineer in good time shall entitle the Engineer to reclassify, at his discretion, such excavated material."

PSD 3.1.2 Classes of excavation

Add the following:

"Notwithstanding the provisions of Subclause 3.1.2 of SANS 1200 D, the materials excavated, other than hard rock, will not be classified for the purposes of measurement and payment. The unit rate for excavation shall cover the cost of excavation in all materials with the only extra-over items payable being those for excavation in hard rock."

PSD 3.2 CLASSIFICATION FOR PLACING PURPOSES

PSD 3.2.1 Material suitable for embankments and terraces

Add the following:

"Embankment material shall be compacted to 90% modified AASHTO density."

PSD 3.2.3 Material suitable for backfill or fill against structures

Replace the contents of this Subclause with the following:

"Material used for backfill behind structures shall generally be the material excavated, subject to the following conditions:

(a) The material shall not contain an excessive number of stones retained on a 50 mm sieve;

(b) The material shall not contain large clay lumps that do not break up under the action of the compaction equipment; and

(c) The liquid limit of the material shall not exceed 40, neither shall the PI exceed 18"

PSD 3.3 SELECTION

Add the following subclause:

"PSD 3.3.3 Selection in borrow pits and excavations

Approval of a borrow area for a certain purpose does not necessarily mean that all the material in that area is suitable for the specified purpose. What it does mean is that the borrow area contains some suitable material. The onus shall rest on the Contractor to ensure that only material that is indeed suitable is removed and used for the specified purpose.

When the Contractor has to select excavated material for a specific purpose, the above provisions relating to borrow areas shall apply *mutatis mutandis* to excavations.

The Contractor shall not waste or contaminate material that has been selected for a specific purpose."

PSD 4 PLANT

PSD 4.4 DETECTORS

Replace the contents of Subclause 4.4 with the following:

"The Contractor shall, for the purposes of detecting and locating underground services in accordance with the provisions of subclause 5.4 of SANS 1200 A and subclause 5.1.2 of SANS 1200 D, at his own cost, provide and use detecting equipment which is suitable for the detection of underground cables and pipes."

Add the following new item in Subclause 4:

"PSD 4.5 RESTRICTION ON USE OF PLANT

Where the Contractor finds it impractical to use mechanical plant for excavation or to complete portions of the work due to restrictions caused by difficult access or the presence of existing structures, pipelines or services shown on tender drawings, the Contractor will be deemed to have satisfied himself as to the alternative requirements when entering rates against the appropriate items in the Bill of Quantities as no claim for extra payment based on the inability to use plant in such circumstances will be considered."

PSD 5 CONSTRUCTION

PSD 5.1 PRECAUTIONS

PSD 5.1.1 Safety

PSD 5.1.1.1 Barricading and lighting

Replace "Machinery and Occupational Safety Act, 1983 (Act 6 of 1983)" *with* "Occupational Health and Safety Act, 1993 (Act 85 of 1993)."

Add to the sub-clause:

"Without limiting any obligation which the Contractor may have in terms of any Act, Ordinance or other legislation, the Contractor shall ensure that all excavations which are accessible to the public or which are adjacent to a public road or thoroughfare, or by which the safety of persons may be endangered are protected as set out in Clause 13 of the General Safety Regulations of the Occupational Health and Safety Act, 1993 and that Watchmen are employed to ensure that barricades, barriers and lights are effective at all times.

Trench excavations shall be protected by means of at least seven horizontal wires with double sided red/white; chevron tape wrapped over the wires as approved by the Engineer for a height of 1.2 m above ground. For excavation depths exceeding 2 m, the height of the fencing shall be increased to 1.8 m with an additional 4 strands of wire. The wires shall be stretched tightly between supports along both sides and ends of the excavation, equally over the full height of the support. The supports shall consist of poles or iron standards securely planted in solid ground at not more than 10m centres so as to enclose the spoil and the excavations.

Bridges for vehicles and/or pedestrians shall be provided along the route of the work as and where may be considered necessary by the Engineer. They shall consist of a number of suitably sized steel plates laid across open excavated trenches. They shall be protected on each side by steel handrails, at least 1m high, securely fastened to the steel plates. At least 4 lamps or reflective markers must be provided at each crossing.

Where construction is in, or across, public roads the barricades or barriers and temporary road signs shall be erected. All such signs and positioning thereof shall comply with the requirements set out in Road Note 13 read in conjunction with the SA Road Traffic Signs Manual."

PSD 5.1.1.2 Safeguarding of excavations

Replace "Machinery and Occupational Safety Act" *with* "Occupational Health and Safety Act, 1993 (Act 85 of 1993)."

Add the following sub-paragraph:

"(g) The Contractor or his agent or his representative shall not require or allow any person to work under unsupported overhanging material or in an excavation which is more than 1,5 m deep, and any excavation which has not been adequately supported or braced if there is a danger of the overhanging material or the sides of the excavation collapsing. The support, shoring or bracing to be designed and constructed by the Contractor, shall be strong and sturdy enough to support the sides of the excavation in question."

PSD 5.1.1.3 Explosives

Replace the contents of this Subclause with the following:

"The Contractor will generally be permitted to use explosives for breaking up hard material during excavations, for demolishing existing structures, and for other purposes where explosives are normally required, subject to the following conditions:

a) The Engineer may prohibit the use of explosives in cases where, in his opinion, the risk of injury to persons or damage to property or to adjoining structures is too high.

b) The Engineer's prior written approval shall be obtained for each and every blasting operation. This approval may be withheld if the Contractor does not use explosives responsibly and carefully.

c) The Contractor shall comply fully with the requirements of the Explosives Act, 1997 (Act No 83 of 1997) and all other legislation and regulations as may be applicable to blasting and the use of explosives.

d) Before blasting is undertaken, the Contractor shall satisfy the Engineer that he has established whether or not the insurers concerned require pre- and post-blasting inspections of buildings and structures within a certain radius of the proposed blasting.

   Should such inspections be required, the Contractor shall, together with the Engineer and the insurer, examine and measure the buildings, houses or structures in the vicinity of the proposed blasting site and establish and record, together with the owner, lessee or occupier, the extent of any existing cracking or damage before blasting operations commence.

e) When there is a possibility of damage to power and telephone lines or any other services or property, the Contractor shall adapt his method of blasting and the size of the charges and shall use adequate protective measures (eg cover-blasting) to reduce the risk of damage.

f) All accidents, injury to persons and animals and damage to property shall be reported to the Engineer in detail and in writing as soon as is practicable.

g) The Engineer shall be given 24 hours' notice by the Contractor before each blasting operation is carried out.

h) When blasting to specified profiles, the Contractor shall so arrange the holes and charges so that the resulting exposed surfaces are as sound as the nature of the material permits. The Contractor shall make good, at his own expense, any additional excavation necessitated by the shattering of rock in excess of any overbreak allowances specified or given on any Drawing.

i) The design level shall be achieved using grade 15 MPa/19 mass concrete to fill areas where excessive overbreak occurred. The cost to fill overbreak areas with mass concrete shall borne by the Contractor and he shall not be able to claim any delays as a result of filling overbreak.

Notwithstanding the Contractor's compliance with the above provisions, the Contractor shall remain liable for any injury to persons and animals and loss of or damage to property occurring as a result of blasting operations."

PSD 5.1.2 Existing services

PSD 5.1.2.1 General

Add to the sub-clause:

"All existing services on the site may not be shown on the Drawings or be visible on the site. The Engineer may order excavation by hand in order to search for and expose services. An item has been included in the Bill of Quantities to cover the cost of such work if so ordered by the Engineer.

Where a service is damaged because of the Contractor's negligence, he shall be liable for the costs involved in the repair of the service and any other costs consequent upon the interruption of the damaged services."

PSD 5.1.2.2 Detection, location and exposure

Replace the contents of Subclause 5.1.2.2 with the following:

"The exposure by the Contractor of underground services, as required in terms of PSA 5.4 of SANS 1200 A amendments shall be carried out by careful hand excavation at such positions and to such dimensions as are agreed to by the Engineer.

Unless otherwise instructed or agreed by the Engineer, no service shall be left exposed after its exact position has been determined and all excavations carried out for the purposes of exposing underground services shall be promptly backfilled and compacted to the following densities:

a) In roadways: 93% Mod AASHTO density; and

b) In all other areas: 90% Mod AASHTO density.

Where hand excavations to expose underground services have to be carried out in roadways, the Contractor shall reinstate the road layerworks in accordance with the provisions of subclause 5.9 of SANS 1200 DB.

Payment in respect of exposing the services by means of hand excavation as described above, will be made in accordance with subclause PSD 8.3.8.1.

Payment in respect of reinstating layerworks in roadways will be made in accordance with subclause 8.3.6.1 of SANS 1200 DB (as amended)."

PSD 5.1.2.3 Protection of cables

Replace Subclause 5.1.2.3 with the following:

"5.1.2.3 Protection during construction

Further to the requirements of subclause PSA 5.4.2 of SANS 1200 A amendments, major excavating equipment and other plant shall not be operated dangerously close to known services. Where necessary, excavation in close proximity to known services shall be carefully carried out with suitable hand tools, excluding picks wherever their use could damage the services. No additional payment will apply to such more difficult work.

Should any service not being a known service be discovered or encountered during the course of the Contract, the Contractor shall, in addition to complying with the requirements of subclause PSA 5.4.2 of SANS 1200 A amendments, immediately notify the Engineer thereof and implement such measures as will prevent damage of such service or, if it was damaged in the course of discovery, will prevent and minimise the occurrence of any further damage occurring."

PSD 5.1.2.4 Negligence

Delete Subclause 5.1.2.4.

PSD 5.1.3 Stormwater and groundwater

Add the following:

"The Contractor shall, where applicable and at the earliest practicable opportunity, install the permanent drainage specified or shown on the Drawings and shall also provide the temporary drainage required to protect the works."

PSD 5.1.6 Road traffic control

Delete the second sentence of Subclause 5.1.6.

PSD 5.2 METHODS AND PROCEDURES

PSD 5.2.2 Excavation

PSD 5.2.2.1 Excavation for general earthworks and for structures

Amend Subclause (a):

DELETE THE FIRST LINE AND REPLACE WITH “After an area has been cleared and the topsoil removed and stockpiled, excavation …… ”

Replace the first sentence of paragraph (e) with the following:

"Where excavations have been carried below the authorised levels, the Contractor shall backfill such excavations to the correct level with approved gravel compacted to 93% of modified AASHTO density or to the density of the surrounding material, whichever is the higher density. The cost of the remedial measures shall be for the Contractor's account.

Where excavations for structures have been carried out in hard material, the Engineer may direct that over-excavation be backfilled with Grade 15 MPa 19 mm mass concrete if there is a danger of settlement or differential settlement of the foundations. The cost of the additional concrete or remedial measures shall be for the Contractor's account.

Where the sides of excavations against which concrete is to be cast have been over-excavated or have collapsed partially, the Contractor shall retrim the excavations if necessary and, unless other remedial measures are agreed to by the Engineer, shall cast the concrete for the structure, including the additional concrete that may be required as a result of the over-excavation or partial collapse. The cost of the additional concrete or remedial measures shall be for the Contractor's account."

PSD 5.2.2.3 Disposal

Replace the second sentence with the following:

"The Contractor shall provide all necessary spoil sites for the spoiling of all surplus and unsuitable materials and shall make the necessary arrangements with the owner of the site where the material is disposed of, and pay all charges and levies as may be applicable for the use of such spoil sites.

Every spoil site provided by the Contractor shall be approved by the local authority in whose area it is located, and the spoiling shall comply with the applicable statutory and municipal regulations as well as the requirements of the owner of the spoil site.

Add the following subclauses in Subclause 5.2.2:

"PSD 5.2.2.4 Selection and stockpiling

Approval or designation of the material in a particular borrow pit or excavation for a particular purpose does not imply that all the material in the borrow pit or excavation is suitable for the particular purpose to which the said approval or designation relates, nor that all material in the borrow pit or source should be used for the particular purpose. The Contractor shall select suitable material from that borrow pit or source, discard unsuitable material and reserve material for other purposes as necessary.

The Contractor shall organise and carry out his operations in such a manner as will prevent the contamination of suitable embankment and backfill material with unsuitable materials. Any excavated material which becomes, in the Engineer’s opinion, unsuitable for use in embankments or backfill as a result of contamination, shall be disposed of in a manner acceptable to the Engineer and shall be replaced by the Contractor with materials acceptable to the Engineer, all at the Contractor’s cost.

When required, or when ordered by the Engineer, material shall be stockpiled for later use. Granular (silty sand), clay (sandy clay) and rock shall be stockpiled separately. The additional costs for stockpiling material shall be paid to the Contractor in accordance with the provisions of new Subclause PSD 8.3.14."

PSD 5.2.2.5 Excavation of hard rock without blasting

Due to the fact that construction may be alongside existing services, pipelines and in certain areas are near structures/buildings, the Contractor shall exert maximum caution in his methods and operations. In such cases, and where instructed by the Engineer, the Contactor shall use non-explosive methods approved by the Engineer. These methods include hand pneumatic hammers, excavator mounted hydraulic hammers (breakers), expansive chemical products, or other method approved by the Engineer.

The application of this Subclause will not relieve the Contractor of his responsibilities in accordance with Subclause 5.1.1.3 of SANS 1200 D or otherwise in terms of the Contract.

PSD 5.2.2.6 Recording of original ground profiles

The Contractor shall inform the Engineer, in writing, at least 28 days before commencing any work which will result in a change in the topography of the site, whether such work be for the permanent works or for temporary works which the Contractor intends to execute for his own convenience. Thereupon, before commencing the work, the Contractor shall undertake cross-sections of the original ground profiles at structures and a centreline survey of the pipeline or another approved method to determine the ground profiles of the entire area to be worked. In addition all rock and/or foundation levels shall be recorded as the work proceeds.

The information so obtained shall be permanently recorded on a drawing or drawings which shall each be signed by both the Contractor and the Engineer. The Contractor shall then provide the Engineer with a reproducible copy of each drawing to serve as a permanent record both for the purpose of redesign, determining the quantities of excavation and earthworks carried out in the construction of the permanent works and the extent to which temporary works shall be removed or temporary excavations shall be refilled upon completion of the Works."

PSD 5.2.3 Placing and compaction

PSD 5.2.3.1 Embankments

In Subclause 5.2.3.1, in the second last paragraph, replace "98%" *with* "100%".

PSD 5.2.5 Transport for earthworks

Replace the contents of Subclause 5.2.5 with the following:

"Refer to PSA 8.9 of SANS 1200 A amendments"

PSD 6 TOLERANCES

No amendments:

PSD 7 TESTING

PSD 7.2 TAKING AND TESTING OF SAMPLES

Replace the contents of this Subclause with the following:

"The Contractor shall arrange with the approved independent laboratory engaged by the Contractor in terms of PSA 7.2 of SANS 1200 A amendments to carry out sufficient tests on a regular basis as agreed between him and the Engineer to determine whether the degree of compaction, and, where applicable, the quality of materials used, comply with the Specifications and shall submit the results of these tests to the Engineer in a form approved by him.

Testing by the Engineer will not relieve the Contractor of his obligations to provide materials and workmanship in accordance with the specifications.

The compaction requirements for fills shall be deemed complied with when at least 75% of the dry-density tests on any lot show values equal to or above the specified density and when no single value is more than five percentage points below the specified value."

PSD 8 MEASUREMENT AND PAYMENT

PSD 8.1 BASIC PRINCIPLES

PSD 8.1.3 Subclause

Replace Subclause 8.1.3 with the following:

“The provision of working space (see Subclause 8.3.5 of SANS 1200 D) will not be measured for payment. Notwithstanding the provisions of Subclause 8.1.3 of SANS 1200 D, the Contractor shall make his own allowance for the excavation of any working space required for formwork or other purposes. The rates for restricted excavation shall also cover the costs of providing working space. All restricted excavation will be measured to the net dimensions of concrete floor slabs or other dimensions ordered by the Engineer.”

PSD 8.3 SCHEDULED ITEMS

PSD 8.3.1 Site preparation

PSD 8.3.1.1 Clear and strip site

Replace Subclause 8.3.1.1 with the following:

"Where site preparation such as clearing, grubbing, and the removal of large trees is required, the provisions and scheduled items of SANS 1200 C shall apply."

PSD 8.3.2 Bulk excavation

Amend the subclause as follows:

No extra-over payment will be made for excavation in material classified in terms of Subclause 3.1.2 of SANS 1200 D as intermediate excavation. The tendered rate for excavation in soft materials shall include for the cost of such excavation.

Separate items are scheduled as follows:

a) hard rock excavation with explosives,

b) hard rock excavation without explosives,

c) boulder excavation Class A, and

d) boulder excavation Class B.

The rate for subitem (a) shall be applicable to methods which use explosives (blasting) for the excavation of hard rock. The rate for subitem (b) shall be applicable to non-explosive methods for the removal of hard rock (eg. using chemicals, machine mounted hydraulic hammers/breakers, or other approved method).

The tendered rate for excavation shall cover the cost of recording the original ground profiles as specified in Sub-clause PSD 5.2.2.6.

PSD 8.3.3 Restricted excavation

Replace the words "in 1 m increments" *at the end of the first sentence of Sub-Item (a) with* "in the increments indicated in the Schedule of Quantities".

Replace "in 5.2.2.1 – 5.2.2.3 (inclusive)" *at the end of Subclause (a) with* "in subclauses 5.2.2.1 to 5.2.2.6 (inclusive)".

Amend the subclause as follows:

No extra-over payment will be made for excavation in material classified in terms of Subclause 3.1.2 of SANS 1200 D as intermediate excavation. The tendered rate for excavation in soft materials shall include for the cost of such excavation.

Separate items are scheduled as follows:

a) hard rock excavation (without explosives),

b) boulder excavation Class A,

c) boulder excavation Class B, and

The rate for subitem (a) shall be applicable to non-explosive methods for the removal of hard rock (eg. using chemicals, machine mounted hydraulic hammers/breakers, or other approved method).

The tendered rate for excavation shall cover the cost of recording the original ground profiles as specified in Sub-clause PSD 5.2.2.6.

Add the following Sub-Item:

"(c) Extra over sub item 8.3.3 (a) for hand excavation...................................... Unit: m³

This item shall apply to hand excavation ordered by the Engineer or when the Engineer considers that, owing to circumstances, excavation by mechanical excavators is not practicable. It shall not apply to hand excavation for trimming or finishing an excavation made by mechanical means.
The tendered rate shall include full compensation for the additional cost of excavating by means of hand tools."

PSD 8.3.4 Importing of materials

Amend the heading of Sub-Item (a) of 8.3.4 to read "…or from borrow pits or from stockpile"

Add the following to the end of the first paragraph:

"..and for each type of material as specified or ordered."

PSD 8.3.6 Overhaul

Delete Subclause 8.3.6.

PSD 8.3.8 Existing services

PSD 8.3.8.1 Location

Replace item 8.3.8.1 with the following:

"**8.3.8.1 Hand excavation for locating and exposing existing services:**

(a)	In roadways	Unit: m^3
(b)	In all other areas	Unit: m^3

The unit of measurement shall be the cubic metre of material excavated, measured in place according to the authorised or actual dimensions of the excavation, whichever is the lesser.

The tendered rates shall cover the cost of excavating in all materials by means of hand tools within authorised dimensions and at locations approved by the Engineer in accordance with the requirements of subclause PSA 5.4.1 of SANS 1200 A amendments for all precautionary measures necessary to protect the services from damage during excavation and backfilling, and for subsequent backfilling and compacting. Compaction of material in all areas except in roadways shall be to 90% of the modified AASHTO density.

The tendered rate for hand excavation in roadways shall include compensation for compacting excavated or selected backfill material to 93% of modified AASHTO density. Reinstating layerworks and surfacing shall be measured and paid for in terms of SANS 1200 DB.

The tendered rates shall also include for keeping excavations safe, for dealing with surface and subsurface water, for removing surplus excavated material from the site, for transporting all material within the free-haul distance, and for supplying adequate supervision during both excavation and backfilling operations."

PSD 8.3.10 Topsoiling

Add the following:

"The topsoiling will be measured by surface area covered.

The rate for topsoiling shall cover the cost of loading, hauling, spreading to a thickness of 150 mm, compacting and making suitable provision to avoid the topsoil slipping down the slopes of embankments and cut-slopes, all to the approval of the Engineer as well as the shaping of surplus stockpiles of topsoil as described in Amendments to SANS 1200 C."

PSD 8.3.12 Road traffic signs and markings

Replace the word "Separate" *in the first sentence of Item 8.3.12 with the following:*

"Where the Engineer requires the provision of road traffic signs and/or road markings and/or any other measures additional to those to be provided by the Contractor in accordance with SANS subclause 5.1.6, separate".

Add the following new subclauses to Subclause 8.3:

"PSD 8.3.14 Extra-over for temporary stockpiling of material .... Unit: m³

The unit of measurement shall be the cubic metre of material from necessary excavations, temporarily stockpiled by the Contractor on the instructions of the Engineer, before being used in embankments or backfill. Measurements shall be taken in place in compacted embankment or backfill as the case may be.

The tendered rate shall include for the costs, additional to those provided for in 8.3.2(a) and 8.3.3, of off-loading, forming and maintaining the stockpile for as long as is required, reloading and transporting within the applicable free-haul distance from the stockpile.

Payments to the Contractor under this item will only be made in respect of that material stockpiled on the instructions of the Engineer (which instruction shall state specifically that payments for such stockpiling will be paid for under this item) and no payments will be made to the Contractor under this item in respect of materials stockpiled by the Contractor on his own volition, nor for materials necessarily stockpiled by the Contractor in consequence of the sequence of operations adopted by him in the course of executing the works, whether such stockpiling was avoidable or otherwise.

PSD 8.3.15 Survey of surrounding structures before blasting.. Unit: Sum

The sum shall cover the cost to examine and measure up any buildings, houses or structures in the vicinity of the proposed blasting and establish and record together with the owners thereof the extent of cracking or damage that may exist before commencement of blasting operations. The rate shall cover the cost of providing a photographic record of neighbouring structures before blasting commences."

PSD 8.3.16 Protection of structures / buildings / services.. Unit: Sum

The sums shall cover the cost of examining and measuring up any underground services, buildings, houses or structures that encroach within the Site and establishing and recording, together with the owners thereof, the general condition and/or damage that may exist before commencement of blasting operations, including the cost of exposing the service, providing a photographic and survey record, and the costs of any special working methods required to protect the structure or service throughout the course of the nearby construction work. This shall include, where required, but is not necessarily limited to, the use of shoring or lateral trench support, concrete encasement of service, and the placing of barriers to demarcate restricted working area in the vicinity of the structure."

PSD 8.3.17 Shaping of designated stockpile area on completion of the Works

The unit of measurement shall be machine hour as scheduled and shall include all costs for overheads, supervision, operator, fuel, maintenance and running costs to shape the balance of material remaining in designated stockpiles, once all the earthwork operations on the Contract are complete, to the satisfaction of the Engineer."

TABLE OF CONTENTS

PSDB 1 SCOPE

No amendments.

PSDB 2 INTERPRETATIONS

No amendments.

PSDB 3 MATERIALS

PSDB 3.5 BACKFILL MATERIAL

(a) *In the third line delete* “150mm” *and substitute* “100mm”.

(b) *In the second line delete* “P.I not exceeding 12” *and substitute* “P.I not exceeding 6”.

Add to the subclause:

“(c) Where shown on the drawings or as directed by the Engineer, backfill shall be stabilised with 5% cement by mass. The backfill material shall have a plasticity index not exceeding 6 and all material must not be bigger than 19 mm.

The dry materials shall first be mixed in a concrete mixer after which sufficient water is to be added to produce the stiffest consistency available for placing and compacting with vibrators.

The soil or gravel shall be mixed with 5% cement and shall be compacted in layers of 100 mm thick to 90% of modified AASHTO density

(d) The aggregate for soilcrete shall be mixed with 5% cement and shall consist of approved soil or gravel containing stones not bigger than 38 mm and with a plasticity index not exceeding 10.

The soil or gravel shall be mixed in a concrete mixer with the cement and enough water to acquire a consistency that allows the mixture to be placed with vibrators to fill all voids between the pipe and the sides of the trench. Shuttering shall be used where necessary."

PSDB 3.6 MATERIALS FOR REINSTATEMENT OF ROADS AND PAVED AREAS

Add to the subclause:

“The materials used in the reinstatement of existing road layers shall comply with the following physical properties:

a)	Subbase:	PI maximum 10. CBR at least 45% at 95% of MAMDD.
b)	Base:	PI maximum 6. CBR at least 80% at 98% of MAMDD.
c)	Surfacing:	Asphalt surfacing as specified in Subclause 3.6.4 of SANS 1200 DB.
d)	Gravel wearing course:	PI maximum 14 but not less than 10. The size of the aggregate shall not exceed 40 mm. CBR at least 45% at 95% of MAMDD.”

PSDB 3.7 SELECTION

Replace the words "if he so wishes*" in the first line of the second paragraph with the words* "at his own cost".

PSDB 4 PLANT

PSDB 4.1 EXCAVATION EQUIPMENT

In the first line delete "The Contractor" *and substitute:* "In sections deemed to be excavated by mechanical means, the Contractor".

Add to the subclause:

"Should any portion of a pipe trench exceed the specified depth, the Contractor will be held responsible for any additional costs which may arise as a result of such over-excavation. Concrete filling or imported compacted fill may be ordered by the Engineer to make good any over-excavation."

"PSDB 4.4 RESTRICTION ON USE OF PLANT

Where the Contractor finds it impractical to use mechanical plant for excavation or to complete portions of the work due to restrictions caused by difficult access or the presence of existing structures, pipelines or services shown on tender drawings, the Contractor will be deemed to have satisfied himself as to the alternative requirements when entering rates against the appropriate items in the Bill of Quantities as no claim for extra payment based on the inability to use plant in such circumstances will be considered."

PSDB 5 CONSTRUCTION

PSDB 5.1 PRECAUTIONS

PSDB 5.1.2 Stormwater, seepage and dewatering of excavations

PSDB 5.1.2.1 Throughout the Works

Add the following new subclause to Subclause 5.1.2.1:

"PSDB 5.1.2.1.1 Groundwater

The provisions of this subclause shall apply to all trench and valve chamber excavations.

Sections of the pipeline and the valve chambers will be laid below the water table and ground water will be encountered during excavation. The Contractor shall dewater the excavations to such an extent as to draw the water table down to at least 100 mm below the top of the crushed stone layer, or bottom of the blinding layer, and keep it there until the backfill to the top of trench is complete."

PSDB 5.1.2.2 Special water hazards

Add to the subclause:

"The Engineer may direct the Contractor to implement subsoil drainage measures at certain sections of the pipe trench where ground water seepage is considered significant. Such drainage measures shall consist of a free draining granular material placed underneath or alongside the pipe, or in separate drainage trenches."

PSDB 5.1.2.3 Sloping ground

Delete the subclause and substitute with the following:

“The Contractor shall be responsible throughout the duration of the Contract, inclusive of the Defects Liability Period, for the provision of all soil erosion preventative measures necessary to protect the trenches, pipeline(s) and land utilized by the Contractor during the Contract from any adverse effects of soil erosion, settlement, scour, etc., resulting from the construction of the Works.

Cross embankments, generally extending across the full width of the working strip, consisting of low earth mounds shaped to rounded form and so oriented as to have a fall of 1% along their length, shall be constructed with compacted material having a minimum density of 90% modified AASHTO density and minimum dimensions and maximum spacings dependent on the slope of the ground along the length of the pipeline, as indicated on the drawings

Cross-embankments shall be constructed to the same minimum standards and dimensions indicated above wherever artificial slopes have been formed on the working strip or other areas used during construction and, with the approval of the Engineer, are permitted to be so left.

Payment will be made for the construction of cross-embankments provided construction thereof has been either ordered or approved by the Engineer prior to the commencement of such construction.”

Add the following new subclauses to Subclause 5.1.2:

“PSDB 5.1.2.4 Cross-walls in trenches

In steeply sloping trenches at between 15 and 20% grade, or where erosion becomes evident on site, or where ordered by the Engineer, the Contractor shall place sacks of earth as cross walls around and above the pipe up to ground level, prior to backfilling, as a soil erosion measure as indicated on the drawings.

Where required, an item will be included in the Bill of Quantities to cover the cost of the supply, installation and maintenance of sack breakers.

PSDB 5.1.2.5 Concrete anchor blocks where gradient equals or exceeds 20%

Where the grade of the pipe equals or exceeds 20% the Contractor shall provide concrete anchor blocks.

Where required, an item will be included in the Bill of Quantities to cover the cost of the supply, installation and maintenance of concrete anchor blocks, including the wrapping of the encased pipe portion with an approved tape wrapping such as Denso Ultraflex or similar approved (refer to Specification AUR 0003).”

PSDB 5.1.3 Accommodation of traffic and access to properties

Replace the semicolon and the word "and" *at the end of Subclause 5.1.3(a) with a full stop and replace item (b) with the following:*

"(b) The Contractor shall provide and maintain pedestrian and vehicular access to properties affected by the works, the Contractor shall construct and maintain to the satisfaction of the Engineer, such temporary access roads around, and/or steel or timber bridges over excavations in roads, pavements, entrances or accesses to properties.

Temporary pedestrian access bridges shall be at least 1,2 m wide and temporary access bridges for vehicles shall be at least 3,6 m wide. All temporary access bridges shall be fitted with handrails as well as protective mesh fencing on both sides.

On completion of the work, the Contractor shall dismantle and remove all such temporary constructions and reinstate these areas to their former condition.

Except only where the Engineer has included in the Schedule of Quantities, particular payment items specifically therefor, the Contractor will not be paid directly for the construction and maintenance of temporary access roads and/or the provision and maintenance of bridges as aforementioned, and the costs thereof shall be deemed included in the Contractor's tendered rates for excavation."

PSDB 5.1.4 Existing services that intersect or adjoin trenches

Delete the clause and replace with the following:

"The requirements of Subclause 5.1.2 of SABS 1200 D in conjunction with PSD 5.1.2 shall apply."

Add the following new subclauses to Subclause 5.1:

"PSDB 5.1.5 Stability of trench excavations

The precautions for excavations as specified in Clause 5.1.1 of SANS 1200 D and the relevant amendments to the Standard Specification's clauses, shall also apply to all trench excavations.

The Contractor shall take all the steps necessary to ensure that no person is required or allowed to work in a trench or any other unsupported overhanging excavation which is more than 1,5m deep, and any excavation which has not been adequately supported, shored or braced if there is any danger whatsoever of the sides of the excavation collapsing. The support, shoring or bracing to be designed and constructed by the Contractor, shall be strong and sturdy enough to support the sides of the excavation in question.

PSDB 5.1.6 Working width

The construction of the Works shall be restricted to the "working widths" indicated on the drawings. The Contractor requires written permission from the Engineer should he wish to work outside the specified "working widths".

PSDB 5.2 MINIMUM BASE WIDTHS

In the 5th line, delete the word "External" *and replace with* "Nominal."

Add to the subclause:

"The base width for trenches for cables, ducts and unbedded flexible continuous piping, of external diameter less than 125mm laid at a depth of 1,0m.

PSDB 5.4 EXCAVATION

Add to the following:

"All pipelines shall be laid to the invert levels and gradients shown on the drawings. Except where otherwise specified, trenches shall be of such a depth that the minimum cover over the pipes shall be 1000 mm except at road-crossings where the minimum cover shall be 1200 mm (as measured from the original ground level to the top of the pipe barrel).

All excavated material shall be kept within the working width and designated sites as indicated on the Drawings and shall be so deposited as not to interfere with or endanger the Works (for example, by causing the sides of the excavation to collapse), other property, or traffic.

The toe of the stockpile shall be trimmed well back from the edge of the trench so as to leave a minimum 1,5 m clearance between the edge of the stockpile and the edge of the trench. The Contractor shall keep this strip clear of excavated material at all times and take all necessary steps to prevent mixing with material set aside for backfill.

The Engineer may, in terms of Subclauses 5.6.3 and 5.6.4, order the Contractor to remove any material which he considers liable to endanger or interfere with the Works, private property, traffic, or pedestrians, and to place such material at some other approved position. If the necessity for such removal is, in the opinion of the Engineer, a result of some default on the part of the Contractor, the cost thereof shall be borne by the Contractor, otherwise the cost will be borne by the Employer at a sum pre-agreed with the Engineer or measured as Daywork, whichever is the more appropriate in the opinion of the Engineer."

PSDB 5.5 TRENCH BOTTOM

Add the following new subclauses to Subclause 5.5:

“PSDB 5.5.1 Jointing holes

Jointing holes shall be cut of sufficient length and depth to allow for the proper making or bolting of pipe joints and to ensure that joint collars or sleeves do not rest on the trench bottoms. After the pipework has been inspected, tested and approved by the Engineer, the jointing holes shall be refilled with selected soft material free from stone (bedding materials as specified under the Amendments to SANS 1200 LB in the case of coated steel pipes) and then rammed to provide a continuous uniform support for the pipework.

No specific payment will be made for forming and refilling holes, the cost of which is deemed to be included in the tendered rates.

PSDB 5.5.2 Unstable trench bottom

The Engineer may, upon consideration of the condition of the trench bottom, particularly with regard to the properties of the soil materials, order the use of a stone layer in order to provide a stable platform for placing of the pipe bedding and laying the pipe in certain sections of the trenches.

The stone layer shall be completely wrapped within a geotextile filter blanket which shall comply with the requirements of SANS 1200 DK and the Amendments, and shall have overlaps of at least 300 mm.”

PSDB 5.6 BACKFILLING

PSDB 5.6.1 General

Add to the subclause:

"Notwithstanding the requirements of Subclauses 5.6.1 and 5.6.6 of SANS 1200 DB, no pipe joint or pipe fitting shall be covered by either blanket or backfill material prior to the successful completion of the visual inspection and pressure testing of the relevant section of the pipeline.

All backfilling shall be carried out by hand and the Contractor must price his tender accordingly. No mechanical plant shall be used in backfilling without prior written consent of the Engineer."

PSDB 5.6.2 Material for backfilling

Delete second paragraph and substitute the following:

"Hard rock material shall not be used for, or incorporated into, the backfill above the bedding layers without the Engineer's approval."

Add to the subclause:

"The final 150mm of the trench shall be backfilled with topsoil which was previously stockpiled. Care must be taken to ensure that the trench is slightly overfilled so that it does not become a rivulet in wet weather."

PSDB 5.6.3 Disposal of soft excavation material

Delete the subclause and replace with the following:

"Except where in the opinion of the Engineer the excavated material is unsuitable for disposal in one or the other of the following methods, surplus material may be spread evenly over the area cleared and grubbed provided it does not raise the original ground level by more than a maximum height of 100mm, or it may be disposed of in a dumping area approved by the Engineer.

Material disposed of in approved disposal areas shall be spread in such a manner that it will not cause water to dam up, and shall be levelled, trimmed and lightly compacted to neat lines and levels."

PSDB 5.6.8 Transport for Earthworks for Trenches

Delete the subclause and substitute:

"Refer to PSA 8.9 of SANS 1200 A amendments"

Add the following subclause:

"PSDB 5.6.9 Backfilling around structures

Backfilling around a structure shall not be commenced before it has been approved by the Engineer.

Granular material shall be used as backfill material around structures as shown on the drawings and shall be placed in layers not exceeding 150 mm compacted thickness, each layer being thoroughly compacted to 100% of modified AASHTO density as instructed by the Engineer before the succeeding layer is placed. Unsuitable or surplus excavated material shall be spoiled off site."

PSDB 5.7 COMPACTION

PSDB 5.7.1 Areas not subject to traffic loads

Add the following sentence:

"All non-cohesive material shall be compacted to 100% MOD AASHTO density."

PSDB 5.7.2 Areas subject to traffic loads

Delete "98%" and substitute with "100%".

Add the following:

"All pipe trenches that fall within the road reserves shall be regarded as areas subject to traffic loads."

Add the following new subclauses:

"PSDB 5.11 TRENCH WALL STABILITY

Notwithstanding the requirements of Subclause 5.4, the Contractor shall take responsibility for the length of trench open at any time and if collapse of the side walls occurs for any reason, the responsibility will be the Contractor's and he will reinstate and make good at his own cost.

PSDB 5.12 RESTRICTED LENGTH OF TRENCH EXCAVATION

The Contractor shall ensure that under all circumstances the maximum open trench length is less than 250 m per work front, but that open trench lengths are sufficient to lay the pipeline at the gradients shown on the drawings. i.e. localised high and low points shall not be permitted if not shown on the drawings. The total length of open trench on all construction fronts shall not exceed 1000 metres (without the approval of the Engineer).

For the sections with high water tables, the Contractor shall dewater the ground, excavate and support the trench and lay, bed and backfill the pipe up to the original ground level, including removal of the trench support and stopping dewatering. A detailed method statement covering the complete operation shall be submitted to the Engineer for approval.

PSDB 5.13 CLEANING UP AS WORK PROCEEDS

The Contractor shall complete all backfilling, trimming, levelling and cleaning up of the Site as work proceeds.

PSDB 5.14 REINSTATEMENT OF EXISTING STORMWATER DRAINAGE INFRASTRUCTURE

The existing furrows and subsurface drainage shall be reconstructed to same dimensions and standards as the existing, unless otherwise ordered or approved by the Engineer. The work shall be carried out as soon as the pipeline (or appurtenant works) has been laid, tested and backfilled.

PSDB 5.15 REINSTATEMENT OF CLEARED AND GRUBBED AREAS

Once backfilling of the pipe trench and any disposal of surplus material over the cleared area (see PSDB 5.6.3) has been completed, the Contractor shall spread and lightly compact the topsoil layer where removed (see PSC 5.6 of SANS 1200 C amendments)."

PSDB 6 TOLERANCES

No amendments.

PSDB 7 TESTING

Add the following to the clause:

"The Contractor shall carry out density tests as specified in TMH1, in the positions indicated by the Engineer, to determine the compaction of the backfill material in the trenches and the material used for reinstating the road construction layers. No single test result which is below the specified density, will be accepted.

In the case of trenches in areas subject to traffic loads, the Contractor shall, notwithstanding the terms of the second sentence of Subclause 7.1, bear the cost of all density tests carried out except as follows. Where the test results are equal to or exceed the specified density, the Employer will bear the cost of that number of those tests ordered by the Engineer in excess of one test per 20 m³ of compacted material, based on the total volume of backfill and reinstated road layers, including the replacement of any over excavation, in areas subject to traffic loads.

In the case of trenches not in areas subject to traffic loads, the Contractor shall undertake one density test per 20 m of installed pipe. The Contractor shall bear the cost of these density tests, unless additional density tests are ordered by the Engineer.

The Contractor shall also bear the cost of those density tests, carried out by the Engineer, of which the test results are below the specified density."

PSDB 8 MEASUREMENT AND PAYMENT

PSDB 8.1 BASIC PRINCIPLES

PSDB 8.1.2 In Subclause 8.1.2(c), amend the last sentence to read:

"The ground surface will be that existing after any bulk excavation has been carried out and before any embankment has been constructed, unless a portion of the embankment has to be constructed in order to achieve an acceptable cover over a pipe that is to be installed, in which case, measurement will be made from the level of embankment that produces an acceptable minimum cover over the pipe."

PSDB 8.1.3 *Add to subclause:*

"No additional payment will be made for excavating and backfilling of jointing (fox) holes as the cost of that work will be deemed to be included in the rates for trenching."

PSDB 8.2 COMPUTATION OF QUANTITIES

PSDB 8.2.3 *Replace the contents of Subclause 8.2.3 with the following:*

“Wherever volumetric measurement is required, the volume will be computed according to the depths indicated on the drawings, or to the bottom of the specified bedding cradle, whichever is the greater, and the width determined from the applicable side allowance set out below (see drawing DB-4) plus the nominal width of the pipe. Side allowance shall be measured from the outside of the pipe. No allowance shall be made for the extra thickness of the collars or couplings.

There shall be 300 mm between a Telkom duct and any other duct/service placed in the same trench.

Where two or more pipes/ducts are to be placed in one trench, the specified base width shall be calculated as follows:

The trench width for the deeper service shall be calculated according to above specifications. The effective trench width for the shallower service shall then be the difference between its specified base width and the overlap with the trench of the deeper service”

PSDB 8.3 SCHEDULED ITEMS

PSDB 8.3.2 Excavation

a) Excavate in all materials, for trenches, backfill compact and dispose of surplus material

*Replace "*of 1,0 m*" in the first sentence of 8.3.2(a) with:*

"as specified in the Schedule of Quantities."

b) Extra over item (a) above for:

Add the following at the end of the existing subitem 2:

"No payments will be made under subitems (1) and (2) in respect of any materials measured and paid for under subitem 3 below."

Add the following to the end of Subclause 8.3.2 b):

"(3) Hand excavation where ordered by the Engineer in:

a) Soft material Unit: m^3

b) Hard material Unit: m^3

The unit of measurement shall be the cubic metre of material, measured in place according to the authorised dimensions, which was excavated by hand on the specific prior written instructions of the Engineer; provided always that the Engineer’s said instruction shall have stated that measurement and payment for such hand excavation will be in accordance with this item.

The tendered rate shall include full compensation for the additional cost, effort and time resulting from excavating in the respective materials using hand methods only.

The Engineer shall not be obliged to authorise payment under this item in respect of any hand excavation carried out (whether ordered in writing or otherwise), which hand excavation was in any case necessary to achieve compliance by the Contractor with his obligations under the Contract to

i) utilise construction appropriate to the nature of the specific parts of the works; and/or
ii) protect existing structures and/or services; and/or
iii) comply with all prevailing legislation and regulations.

(4) Backfill stabilized with 5% cement where directed by the Engineer Unit: m³

The unit of measurement shall be the cubic metre of backfill material, measured in place after compaction according to the authorised dimensions, which was stabilized on the Engineer's instructions in accordance with subclause PSDB 3.5(c).

The tendered rate shall include full compensation for supplying the cement and for selecting, mixing, backfilling and compacting the stabilized material to 90% of modified AASHTO density.

(5) Soilcrete backfill where directed by the Engineer Unit: m³

The unit of measurement shall be the cubic metre of soilcrete placed on the Engineer's instructions in accordance with subclause PSDB 3.5(d), measured in place according to the authorised dimensions.

The tendered rate shall include full compensation for supplying the cement and for selecting, mixing and placing the soilcrete as well as for the cost of shuttering if required.

(6) Restricted working widths Unit: m

Extra-over payment will be scheduled for the following restricted working categories:

a) 5 – 10 m
b) 10 – 15 m
c) 15 – 25 m

The extra-over rates shall cover the costs associated with the method of excavation employed, including all bracing, shoring, battering and the like required to ensure safe trench and working conditions, as well as any extra costs involved in handling and transportation of backfilling, compacting and disposing of surplus material."

Add the following subitems in 8.3.2 after subitem 8.3.2(c):

"(d) Excavate in all materials for stormwater inlet and outlet structures and for manholes, catchpits, valve chambers and the like, irrespective of depth, and backfill around structures: Unit: m³

The unit of measurement shall be the cubic metre of material excavated, measured in place according to the authorised dimensions, and excluding the volume of material excavated and paid for under subitem (a).

The tendered rate shall include for the costs of excavating in all materials, backfilling, compacting, trimming and tidying the final surface around the structure, disposing of surplus and unsuitable materials within the free-haul distance and, where applicable, selecting and keeping separate, excavated material suitable for use as backfill.

(e) Excavate open drains in all materials **Unit: m³**

The tendered rates shall include full compensation for excavating in all materials within the dimensions specified or authorised by the Engineer and to the specified lines and profiles, for the disposal of surplus and unsuitable excavated material where applicable, and in the case of item (d), for backfilling with suitable approved material compacted to 90% of modified AASHTO density around the structures.

(f) Extra over subitems (d) and (e) for excavating in:

(1) Hard rock material Unit: m³

Measurement and payment shall be in accordance with the provisions of 8.3.2(b) of SANS 1200 D (as amended)."

PSDB 8.3.3 Excavation ancillaries

PSDB 8.3.3.4 Overhaul

Delete the contents of this subclause and replace with the following:

"Refer to PSA 8.9 of SANS 1200 A amendments"

PSDB 8.3.4 Particular Items

Replaced the contents specified in (a) with the following:

"Shoring

Any shoring required due to the working width being restricted shall be deemed to be covered under the rates tendered for the items specified in PSDB 8.3.2 (6)."

PSDB 8.3.5 Existing services that intersect or adjoin a pipe trench

b) Services that adjoin a trench

Add to the end of the subclause:

"(v) all work involved in locating the service by hand excavation

(vi) notifying and attending upon the proprietor of the service

(vii) supporting and protecting the service while the pipeline is installed, inspected, tested and backfilled."

PSDB 8.3.6 Finishing

PSDB 8.3.6.1 Reinstate road surfaces complete with all courses

Insert the following after the comma in the sixth line:

"importation of material from commercial sources if required by the Engineer to restore each road course to its original state or better"

Add the following items to subclause 8.3:

"PSDB 8.3.8 Reinstatement of existing stormwater infrastructure approved

The reinstatement of furrows and subsurface drainage will be measured separately by length.

Sections of the furrows and canals which are measured in accordance with Subclause 8.3.5 will not be measured under this item.

The rates shall cover the cost of reconstructing the furrows and subsurface drainage to the dimensions and standards of the existing, including the provision of all plant, labour and materials required to complete the work.

PSDB 8.3.9 Temporary stockpiling of wet material from trench excavations

The excavation and stockpiling of material which is too wet, will be measured by the volume, based on the specified trench width, depth and length, which the Engineer orders to be removed.

The rate shall cover the cost of all operations required to handle, transport to a suitable site and spread to allow the material to dry sufficiently, as well as any costs for disruptions, delays and associated overhead costs resulting from drying out the material.

Should the material which is replaced in the trench become too wet again, due to the fact that the Contractor made insufficient provision for the handling and removal of groundwater in accordance with Subclause 5.5 of SABS 1200 A, the Contractor shall replace the material at his own cost with material which is, in the opinion of the Engineer, suitable.

PSDB 8.3.10 Crushed stone bedding layer and geotextile filter blanket

Where the use of a layer of crushed stone in the trench bottom has been authorised by the Engineer, it will be measured by volume calculated according to the length multiplied by the specified thickness and specified minimum base width.

The rate shall exclude the cost of all additional excavation and preparation of the trench bottom to accommodate the layer of stone, the removal of unsuitable material, but cover the supply and placing of a layer of stone at least the specified thickness over at least the specified width and all related activities in order to produce a stable platform.

The geotextile filter blanket shall be measured by area as:

Area = 2 x (specified thickness + minimum base width) x net length.

The rate shall include the cost of supply, placing and losses as a result of overlaps and over excavated trench widths.

PSDB 8.3.12 Dealing with stormwater, seepage and dewatering of excavations

See PSA 8.8.7 of SANS 1200 A amendments.

PSDB 8.3.13 Cement stabilization

See PSLB 8.2.6."

TABLE OF CONTENTS

Page

PSDK 1 SCOPE

No amendments.

PSDK 2 INTERPRETATIONS

No amendments.

PSDK 3 MATERIALS

PSDK 3.1.2 Gabion cages

Delete the second sentence in Subclause 3.1.2 and replace with the following:

"The wire used for the fabrication of wire mesh cages and for lacing and bracing operations shall be plain zinc-coated mild steel wire. No PVC coating will be acceptable.

The gabion cages shall be as follows:

Gabion cages shall be constructed of double twisted, hexagonal wire mesh gabions of nominal 80mm mesh, with minimum 3,4mm diameter frame wire and minimum 2,7mm diameter mesh wire. For lengths 2m and greater partitions shall be placed at 1m centres. All wire is to be mild steel in accordance with Clause 4.2.1 of SANS 1580 – 2005.

The revetment (reno) mattresses shall be as follows:

The revetment mattresses shall be constructed of double twisted, hexagonal wire mesh gabions of nominal 60mm mesh, with minimum 2,5mm diameter frame wire and minimum 2,2mm diameter mesh wire. For lengths 2m and greater partitions shall be placed at 1m centres. All wire is to be zinc-coated mild steel in accordance with Clause 4.2.1 of SANS 1580 – 2005."

PSDK 3.1.3 Geotextile

Add to the subclause:

"Unless otherwise stated elsewhere the Geotextile filter blanket shall consist of "non-woven" needle-punched polyester fabric having a mass of between 150 and 250g/m², a strength of at least 10 kN/m in all directions and a pore size of between 160 and 210 micron as defined by the Franzius Institute."

PSDK 3.2 PITCHING

PSDK 3.2.1 Stone

In Table 2, Column 2, for extra heavy, *replace* "300" *with"* 600".

Add the following subclause:

"PSDK 3.3 RIPRAP

Riprap shall consist of strong durable blocks of approved hard rock, well graded from a maximum dimension of 400 mm to a minimum of 50 mm and free of earth and quarry fines. At least 50% by weight of the riprap shall consist of blocks over 20 kg and with a minimum equivalent spherical dimension of 250 mm."

PSDK 4 PLANT

No amendments.

PSDK 5 CONSTRUCTION

PSDK 5.2.3 Assembly

Add to the subclause:

"All gabion and mattress cages shall be connected to adjacent gabion and/or mattress cages by lacing the adjacent selvedge's together with 3,7mm diameter galvanized steel wire in accordance with Sub-Clause 4.3.2 of SANS 1580, the same wires to be used for lacing."

PSDK 5.2.4 Rock Filling

Add to the subclause:

"Particular care shall be taken in filling gabions and mattresses so as to ensure that the voids in the rock fill are reduced to the minimum which can be reasonably achieved. In order to minimise the voids in the rock filling, the filling shall proceed in layers not exceeding 300mm deep and each layer shall be rodded and barred so as to compact the rock fill before filling of the next layer commences. Where appropriate, hand packing of selected rock particles shall be carried out."

PSDK 5.2.4.2 Mattresses used in revetments and aprons

Add to the subclause:

"Where gabions and mattresses are placed in exposed positions the rock particles forming the exposed faces shall be specially selected so as to present a fair and even surface."

Add the following subclause:

"PSDK 5.4 RIPRAP

Riprap material shall be placed by dumping as construction of the embankment proceeds. No compaction is required. Dumping shall be carefully controlled to avoid segregation and to produce an even thickness and appearance. Hand labour and suitable plant such as a backactor shall be employed to trim the riprap to the required tolerances and produce a neat appearance."

PSDK 6 TOLERANCES

No amendments:

PSDK 7 TESTING

No amendments:

PSDK 8 MEASUREMENT AND PAYMENT

PSDK 8.2 SCHEDULED ITEMS

PSDK 8.2.2 Gabions

Add the following to Subclause 8.2.2:

"The rates for gabions shall cover the cost of both the bed preparation for the gabions stated in Subclause 8.2.1 as well as the cost of the gabions as stated in Subclause 8.2.2."

Add the following new subclause:

"PSDK 8.2.8 Riprap Unit : m^3

Riprap will be measured by volume calculated as the product of the specified thickness and the area covered.

The rate shall cover the cost of supplying, dumping and trimming the riprap."

TABLE OF CONTENTS

Page

PSDM 1 SCOPE

No amendments.

PSDM 2 INTERPRETATIONS

No amendments.

PSDM 3 MATERIALS

PSDM 3.2 CLASSIFICATION FOR PLACING PURPOSES

PSDM 3.2.3 Selected layer

Replace the contents of this subclause with the following:

"The following requirements shall apply in respect of the selected layer:

a) Maximum particle size: 60% of compacted layer thickness

b) Unstabilized selected layer

c) Upper selected or selected layer

Minimum CBR at 93% of modified AASHTO density: 15

Maximum PI: 12 (the Engineer has the right to alter this requirement to 3 x the grading modulus + 10)

d) Lower selected layer

Minimum CBR at 90% of modified AASHTO density: 7

Maximum PI: 12 (the Engineer has the right to alter this requirement to 3 x the grading modulus + 10)

e) Stabilized selected layer

Minimum grading modulus of natural material: 0,75

UCS of stabilized material 300 kPa - 500 kPa at 93% of modified AASHTO density

Maximum PI for stabilized material: 10"

PSDM 4 PLANT

No amendments.

PSDM 5 CONSTRUCTION

PSDM 5.2 METHODS AND PROCEDURES

PSDM 5.2.2 Cut and borrow

PSDM 5.2.2.3 Use of material

Add the following:

"(e) Commercial sources

The provisions of Subclause PSA 8.9 of SANS 1200 A amendments shall apply."

PSDM 5.2.2.6 Catchwater mounds and channels and mitre banks and channels

Add the following sentence:

"Catchwater mounds and mitre banks shall be compacted to a minimum density of 90% of modified AASHTO density."

PSDM 5.2.3 Treatment of the road-bed

PSDM 5.2.3.2 Removal of unsuitable ground

Replace the second sentence of paragraph (a) with the following:

"The excavated spaces shall then be backfilled with approved imported material or material from other excavations compacted to the required density."

Add the following sentence to paragraph (b):

"Unsuitable excavated material will be paid for as cut to spoil."

PSDM 5.2.3.3 Treatment of road-bed

Add the following paragraph:

"(c) Three-pass roller compaction

Any portion of the roadbed that is shown on the Drawings or is specified or is directed by the Engineer to be given three-pass roller compaction because of its inadequate natural density, shall be prepared by shaping where necessary and compacting with a roller, complying with the requirements specified below.

Compaction shall comprise three complete coverages by the wheels of the specified roller over every portion of the area that is being compacted. While it is not the intention that the Contractor should apply water to the roadbed for this type of compaction, and while no rigid moisture control will be exercised during compaction, the Contractor shall nevertheless satisfy the Engineer that everything is being done to take full advantage of favourable soil moisture conditions during the rainy season, and that such compaction is as far as possible carried out when the roadbed is neither excessively dry nor excessively wet.

The Engineer has the authority to decide when conditions are favourable for compaction and where such compaction is to be carried out at any particular time, and he has the right to instruct the Contractor to water the roadbed at the Contractor's expense when, in the opinion of the Engineer, the Contractor failed, neglected or refused to comply with these requirements.

The rollers to be used for roller-pass compaction shall conform to the following requirements:

Grid roller: The grid roller shall have a mass of not less than 13,5 t when ballasted, shall be loaded to this mass if required, and shall be moved at a speed of not less than 12 km/h.

Vibratory roller: The vibratory roller shall be capable of exerting a combined static and dynamic force of not less than 120 kN/m width for every metre of loose-layer thickness at an operating frequency not exceeding 25 Hz and shall move at a speed not exceeding 4 km/h."

PSDM 5.2.5 Selected layer

Replace the contents of this Subclause with the following:

"Except with regard to density, the requirements of Subclause 5.2.4 of SANS 1200 DM shall apply. The degree of compaction shall be:

Selected layer: 93% of modified AASHTO density"

PSDM 5.2.8 Transport

Replace the contents of this subclause with the following:

"Refer PSA 8.9 of SANS 1200 A amendments"

PSDM 6 TOLERANCES

No amendments.

PSDM 7 TESTING

PSDM 7.3 ROUTINE INSPECTION AND TESTING

Replace table 2 and the contents of Subclause 7.3.2 of SANS 1200 DM with the following:

"PSDM 7.3.1 The dry density requirements for a particular lot of selected layer or wearing course shall be deemed to be satisfied if the average density and the results of individual tests meet the requirements specified in table 2 below. Refer to SANS 1200 D, Subclause 7.2 as amended for the requirements for fill.

TABLE 2: DENSITIES

Layer	**Specified density (% of modified AASHTO density)**	**Number of tests per lot**	**Average density %**	**Minimum density for any single test, %**
Upper selected or selected layer and gravel wearing course	93	3 and 4 5 6	93,1 93,4 93,6	89,4 89,2 89,0

"

PSDM 8 MEASUREMENT AND PAYMENT

PSDM 8.2 COMPUTATION OF QUANTITIES

Replace Subclauses 8.2.1 to 8.2.3 (inclusive) with the following:

"PSDM 8.2.1 The provisions of Subclause 8.2.1 of SANS 1200 D shall apply.

PSDM 8.2.2 The provisions of Subclause 8.2.2 of SANS 1200 D shall apply.

PSDM 8.2.3 The provisions of Subclause 8.2.2 of SANS 1200 D shall apply."

PSDM 8.2.5 Verifying quantities

Replace the first sentence with the following:

"Before any earthworks are commenced but after completion of any site preparation, the Engineer will, upon a written request from the Contractor, provide cross-sections for the purpose of measurement of earthworks quantities."

PSDM 8.3 SCHEDULED ITEMS

PSDM 8.3.3 Treatment of roadbed

(a) Roadbed preparation and compaction of material to

Add the following:

"The unit of measurement shall be the cubic metre of material recompacted as specified and the volume shall be determined from levelled cross-sections on which are superimposed the levels to which the roadbed is to be constructed. When material is imported to make up the required volume, such material will be paid for as cut or borrow to fill as relevant."

Add the following Subclause:

"(c) Three-pass roller compaction:

(i) Grid roller .... Unit: m²

(ii) Vibratory roller .... Unit: m²

The units of measurement shall be the square metre of roadbed compacted as specified in Subclause 5.2.3.3(c) of SANS 1200 DM as amended for the areas designated by the Engineer.

The tendered rates shall include full compensation for shaping the areas, providing the rollers and compacting the roadbed by means of three roller passes over the entire area."

PSDM 8.3.4 Cut to fill, borrow to fill

Replace the last sentence of this item with the following:

"The unit of measurement shall be the cubic metre of fill and the volume will be calculated in accordance with the authorised dimensions of the embankment and levelled cross-sections.

The tendered rates shall include full compensation for excavating the material as if in soft material, for selecting, loading, transporting, off-loading, watering, mixing and compacting the material as specified. Borrow to fill in this item relates to material from designated borrow areas (provided by the Employer) or material from stockpile.

Where it is required that material is obtained from commercial sources, payment for procuring the material will be made under PSDM 8.3.17."

PSDM 8.3.5 Selected layer compacted to 93% of modified AASHTO maximum density

Replace the heading and the contents of this item with the following:

"Selected layer using material from commercial sources, designated borrows pits or excavation:

(a) Compacted to 90% of modified AASHTO density .... Unit: m³

(b) Compacted to 93% of modified AASHTO density .... Unit: m³

The unit of measurement shall be the cubic metre and the quantity will be calculated from the authorised dimensions of the compacted layer.

The tendered rates shall include full compensation for excavating the material as if in soft material for loading, transporting, off-loading, spreading, watering, mixing, breaking down and compacting the layer.

Separate items will be provided for material from each type of source."

PSDM 8.3.6 Extra over items 8.3.4 and 8.3.5 for excavating and breaking down material in

Replace the heading of this item with the following:

"**Extra over items 8.3.4, 8.3.5 and 8.3.16 for excavating and breaking down material in**"

Replace the words "items 8.3.4 and 8.3.5" *with the words* "items 8.3.4, 8.3.5 and 8.3.16".

PSDM 8.3.7 Cut to spoil or stockpile from

Replace the heading with the following:

"Cut to spoil from"

PSDM 8.3.12 Overhaul

Delete the subclause and replace the following:

"Refer PSA 8.9 of SANS 1200 A amendments"

PSDM 8.3.16 Gravel surface layer

Replace the contents of this item with the following:

"The unit of measurement shall be the cubic metre of gravel surface layer and the quantity will be determined from the authorised dimensions of the compacted layer.

The tendered rate shall include full compensation for excavating the material as if in soft material, for loading and transporting the material, off-loading, spreading, breaking down, watering, mixing and compacting the material."

Add the following new subclauses to Subclause 8.2:

"PSDM 8.2.17 Extra over items 8.3.4 and 8.3.16 for obtaining material from commercial source .... Unit: m^3

The tendered rate shall include full compensation for the additional cost of finding a suitable source of material, for procuring the material and paying all royalties or other charges to the owner of the source, for transporting the material to the point of use regardless of the distance hauled and for excavating in intermediate, hard or boulder material as required.

Items 8.3.6, 8.3.12 and 8.3.14 of SANS 1200 DM do not apply to material obtained from commercial sources.

PSDM 8.2.18 Final finishing and cleaning up of the site of the works .... Unit: Sum

The tendered sum shall include full compensation for the clearing, disposal of material, finishing, tidying and all other work required to finish and clean up the Site of the works and affected areas by removing excess earth, stones, boulders, debris and other waste material, by clearing stormwater inlets and outlets and pipe barrels, by clearing the surfacing of all dirt, mud and foreign material, and by neatly finishing off all junctions, intersections and kerbing."

TABLE OF CONTENTS

PSH 1 SCOPE

No amendments.

PSH 2 INTERPRETATIONS

No amendments.

PSH 3 MATERIALS

PSH 3.1 STRUCTURAL STEEL

Add the following to the first paragraph of Subclause 3.1.1:

"Unless otherwise stated, the grade of steel for all members shall be Grade S355JR and shall comply with the requirements of SANS 1431."

PSH 3.6 BOLTS, NUTS AND WASHERS

PSH 3.6.1 Bolts and nuts (other than friction-grip)

Add the following:

"All bolts, nuts and washers within water retaining structures or exposed to the rain, or with a diameter of 10 mm or less, all anchor bolts of any size in concrete or brickwork and all bolts of any size used in conjunction with stainless steel items, shall be manufactured from Grade 304L stainless steel, unless otherwise specifically noted in the drawings.

All other bolts, nuts and washers with a diameter of 12 mm or greater shall be hot-dip galvanized to SANS 121, unless otherwise specifically noted in the drawings. Nuts shall be tapped before galvanizing, taking into consideration the extra clearance necessary to allow for the thickness of galvanizing on the bolts. If, after installation, there is any indication that galvanising has been stripped from either the nut or the bolt, both nut and bolt shall be removed and replaced.

Bolts for structural steel shall be Class 8.8 bolts unless otherwise noted on the drawings."

PSH 4 PLANT

No amendments.

PSH 5 CONSTRUCTION

PSH 5.1 DRAWINGS AND SHOP DETAILS

PSH 5.1.1 Design drawings

Add the following:

"The Contractor shall be solely responsible for the final verification of all steelwork dimensions before preparing his shop drawings and manufacturing any steelwork components."

PSH 5.1.2 Contractor provides shop details

Add the following:

"The Contractor shall be responsible for the preparation, in accordance with SANS2001-CS1:2012, of shop drawings and/or details. The drawings shall be submitted for approval at least two weeks prior to commencement of fabrication. The Engineer shall require seven working days for the approval of shop drawings/details submitted by the Contractor."

PSH 5.2 FABRICATION

PSH 5.2.1 General

Add the following:

"The main structural members shall be single full length."

PSH 5.2.4 Holes for fasteners

Add the following to Subclause 5.2.4.2:

"Holes for fasteners shall be drilled. Punching of holes shall only be permitted with the written approval of the Engineer."

PSH 5.2.7 Welding

All welding shall be done by, or executed under the direct supervision of coded welders.

All welds shall be 6 mm FW continuous, unless otherwise specified or agreed.

PSH 5.3 ASSEMBLY

PSH 5.3.9 Protective treatment

Add the following:

"Corrosion protection shall be done in accordance with Specification: DWS 9900 C7 and its amendments.

All structural steel (including purlins/cladding rails and all connections/plates) shall be hot-dipped galvanised in accordance with DWS 9900 C7"

PSH 6 TOLERANCES

No amendments.

PSH 7 TESTING

PSH 7.1 TEST CERTIFICATES

Add the following:

"Test certificates pertaining to steel used for the various members shall be supplied by the Contractor to the Engineer when requested."

PSH 8 MEASUREMENT AND PAYMENT

PSH 8.3 SCHEDULED ITEMS

Add the following new subclause to Subclause 8.3:

"PSH 8.3.14 Structural steel

Items 8.3.1, 8.3.2, 8.3.3, 8.3.4, 8.3.5, and 8.3.13 shall not be measured and paid for separately, but shall be consolidated into one item paid on the basis of a rate per ton."

TABLE OF CONTENTS

PSHA 1 SCOPE

No amendments.

PSHA 2 INTERPRETATIONS

No amendments.

PSHA 3 MATERIALS

PSHA 3.1 STRUCTURAL STEEL

Replace the words “Structural Steelwork" in the heading and in other relevant Clauses, *to read* "Aluminium, Stainless Steel and Structural Steel".”

Add the following:

“Subclause 3.1 of the Amendments to SANS 1200 H shall apply.”

PSHA 3.3 BOLTS, NUTS AND WASHERS

PSHA 3.3.1 Bolts and nuts (other than friction grip)

Add the following to Subclause 3.3.1:

“Subclause 3.6.1 of the Amendments to SANS 1200 H shall apply.”

Add the following new subclauses to Clause 3:

“PSHA 3.4 STAINLESS STEEL

All stainless steel items shall be Grade 304L material.

PSHA 3.5 ALUMINIUM

All aluminium items shall be grade M57S material anodized in accordance with SANS 999 Grade 25.”

PSHA 4 PLANT

No amendments.

PSHA 5 CONSTRUCTION

PSHA 5.2 FABRICATION AND ASSEMBLY

PSHA 5.2.6 Handrails

Add the following:

“The handrails shall be manufactured by approved manufacturer specialising in such work and shall be of galvanised steel tubing of nominal thickness 2,6 mm and of normal outside diameter at least 34 mm. Where "heavy duty" stanchions are scheduled, they shall be manufactured from tube 3,24 mm thick and be not less than 48 mm in outside diameter.

Stanchions shall be manufactured preformed in one piece and shall be at least 42 mm nominal outside diameter. The bases of the stanchions shall be preformed to suit the situation in which they are to be installed, and the stanchions and spheres shall be preformed to suit right angled or other angled intersections as shown on drawings.

Stanchions shall be spaced at intervals not exceeding 1,6 m. all joints shall be welded after the erection of handrails. Typical details of the handrails and stanchions are given on Drawings.

At certain positions where it shall be necessary to have infrequent access to parts of the works which shall normally be equipped with handrails, the handrails shall over the sections be replaced with guard chains. The guard chains shall consists of 8 mm diameter galvanized chain secured to the stanchions with hooks. It shall only be possible to unhook the chain at one end."

PSHA 5.2.8 Open grid floors

Add the following to Subclause 5.2.8.1:

"Open grid floors shall be manufactured by approved manufacturer specialising in such work and shall be of galvanised steel tubing of nominal thickness 2,6 mm and of normal outside diameter at least 34 mm.

All open grid floor panels shall be banded unless specified on the drawings and shall be made up of manageable strips/panels (i.e. weight not more than 50 kg or area not more than 1,0 m^2)."

Add the following new subclauses to Subclause 5.2:

"**PSHA 5.2.11 Sluice gates**

All sluice gates shall be four-sided sealing, with rising spindle and clockwise closing handwheels. The gates shall seal against on seating pressure. The gate, frame, spindle and handwheel shall be manufactured from stainless steel. The frame is to be installed with the dimensions specified being the clear dimensions.

PSHA 5.2.12 Ladders

Ladders shall be manufactured in accordance with the details and general arrangements shown on the drawings in lengths suitable for hot dip galvanizing. All ladders and their fixings shall be galvanized. All ladders shall be supplied complete with all necessary bolts, nuts and washers for fixing.

PSHA 5.2.13 Corrosion protection

The chequer plate flooring panels, open grid floors and guard chains shall be hot-dip galvanized in accordance with Specification: DWS 9900 C7."

PSHA 6 TOLERANCES

No amendments.

PSHA 7 TESTING

No amendments.

PSHA 8 MEASUREMENT AND PAYMENT

PSHA 8.3 SCHEDULED ITEMS

PSHA 8.3.6 Corrosion protection

Replace the contents of Subclause 8.3.6 with the following:

"Corrosion protection will not be measured separately, the prices tendered for the steel items being held to include for the cost of corrosion protection as specified. (Refer to Particular Specification DWS 9900 C7)."

TABLE OF CONTENTS

Page

PSHB 1 SCOPE

No amendments.

PSHB 2 INTERPRETATIONS

No amendments.

PSHB 3 MATERIALS

PSHB 3.2 STEEL SHEETING

Add the following new subclause:

"PSHB 3.2.4 Zincalume Sheeting

The roof sheeting shall be Global Roofing "Klip-Lok 406" sheets in single lengths made from 0,53 mm thick zincalume heavy industrial (AZ 150), Grade G550 (minimum yield strength 550 MPa) sheeting with "Colorbond" finish to one side (colour: white) and half coat "Colorbond grey" to the other side."

PSHB 3.7 FASTENERS

PSHB 3.7.1 General

Add the following:

"The cladding fasteners shall be in strict accordance with the manufacturer's specifications."

PSHB 3.8 RAINWATER GOODS

Add the following:

"Flashing and ridge capping shall be manufactured from the same material used for the roof sheeting.

Rainwater goods shall be galvanized steel and finished in a colour to match the roof sheeting."

PSHB 4 PLANT

No amendments.

PSHB 5 CONSTRUCTION

PSHB 5.5 INSTALLATION OF SHEETING

Add the following:

"Construction shall be in accordance with the manufacturer's guidelines."

PSHB 5.6 FLASHINGS

Add the following:

"Construction shall be in accordance with the manufacturer's guidelines."

PSHB 5.7 PROTRUSIONS THROUGH SHEETED SURFACES

Add the following:

"Construction shall be in accordance with the manufacturer's guidelines."

Add the following new subclause to Clause 5:

"PSHB 5.8 DETAIL DRAWINGS

The Contractor shall be responsible for preparing drawings of all sheeting/flashing/insulation details required (including details of the fasteners which he proposes to use). The drawings shall be submitted for approval at least two weeks prior to commencement of fabrication.

The Engineer shall require seven working days for the approval of the detail drawings submitted by the Contractor. No sheeting work shall be permitted to commence until such time as the detail drawings have been approved."

PSHB 6 TOLERANCES

PSHB 6.2 INSTALLATION

PSHB 6.2.2 Sheeting and cladding

Add the following:

"The maximum deviation from the theoretical position of sheeting/flashing lines shall be ±5 mm.

The maximum deviation from the straightness of sheeting/flashing lines or abrupt change in same shall be 3 mm. the deviation shall be measured as the maximum deviation of the surface from any straight line of length 3 mm joining two points on the surface, determined by means of a straight edge, the ends of which are supported on identical blocks of suitable thickness placed over each of the points."

PSHB 7 TESTING

No amendments.

PSHB 8 MEASUREMENT AND PAYMENT

PSHB 8.2 SCHEDULED ITEMS

PSHB 8.2.2 Supply and install cladding and sheeting

Add the following:

"The rate tendered shall also include for the cost of corrosion protection as specified and the cost of producing and submitting detailed drawings as required in New Subclause 5.8 in Clause 5.2 of the Amendments to SANS 1200 HB."

PSHB 8.2.3 Supply and install ancillaries

Add the following:

"The rate tendered shall also include for the cost of corrosion protection as specified and the cost of producing and submitting detailed drawings as required in New Subclause 5.8 in Clause 5.2 of the Amendments to SANS 1200 HB."

TABLE OF CONTENTS

Page

PSL 1 SCOPE

Replace the contents of this subclause with the following:

"The SANS 1200 L specification and amendments only applies to HDPE, PVC-U and PVC-M pipes used in medium-pressure applications.

For the manufacture, laying, jointing and corrosion protection requirements of medium-pressure steel pipes, specials, couplings, pipe supports and valves, refer to particular specifications under C3.3 and associated amendments under C3.2."

PSL 2 INTERPRETATIONS

No amendments.

PSL 3 MATERIALS

PSL 3.7.2 Polyethylene pipes

Replace the contents of this subclause with the following:

High density polyethylene (HDPE) pipes shall all be of material PE100 and comply with the requirements of SANS ISO 4427.

PSL 3.8 JOINTING MATERIALS

Add the following new subclauses to Subclause 3.8:

"PSL 3.8.2.5 Pipe Couplings

a) HDPE pipes shall be joined by means of butt fusion welding. HDPE pipes of DN 110 and smaller can be joined with compression type fittings. Electro-fusion fittings will not be accepted.

b) PVC-U / PVC-M pipes shall use push in joints. The pipe end shall be spigot and socket with integral socket and locked-in rubber ring seal.

PSL 3.8.9 Couplings between pipe materials and specials

a) HDPE / steel pipe:

   The HDPE pipe shall be fitted with a stub and grade 304 stainless steel backing ring, which shall be bolted to the flange fitted to the steel special. Mechanical couplings shall not be used to join plain ended HDPE and steel pipes.

b) PVC-U & PVC-M / steel pipe:

   The stainless steel special shall be flanged. A ductile iron or cast iron flange adapter with spigot end shall be used to connect the flanged special to the PVC pipes. An insulating flange shall be provided to prevent bi-metallic corrosion between the stainless steel and ductile iron specials."

Add the following new subclauses:

"PSL 3.12 MARKING

All pipes, specials and valves arriving on site shall be marked clearly with the item number appearing in the Bill of Quantities. Furthermore the nuts, bolts, washers and other ancillary equipment for each individual items shall be kept separate in a bag which shall also bear the respective reference number for that item. The cost of such marking will be held to have been included in the rates tendered for the items.

PSL 3.13 PROTECTION DURING STORAGE, HANDLING AND CONSTRUCTION

The Contractor shall satisfy the Engineer that the manufacturers' recommendations for good practice for the transporting, handling, stacking, storing and installing of pipes, pipe fittings, sealing rubbers etc. are being diligently followed. The Engineer's Representative shall be given the opportunity to inspect all materials immediately prior to installation and shall have the right to reject any materials which, in his opinion, have suffered damage which may impair the long term durability or strength of said items.

Pipes and specials shall be protected against damage during all stages of manufacture, delivery, storage and handling.

Until required, rubber rings and couplings in which there are rubber rings shall be stored undercover in a cool, dark place, away from grease, oil and harmful chemicals. If rubber rings are tied in bundles they shall be untied at least 2 days before being required to allow the rubber rings to recover from any tie marks and indentations."

PSL 4 PLANT

No amendments.

PSL 5 CONSTRUCTION

PSL 5.1 LAYING

PSL 5.1.1 General

Add the following:

"The pipelines shall be laid to the invert levels and gradients shown on the drawings.

Horizontal and vertical angular deviations at flexible couplings shall be limited to the maximum angle specified by the pipe manufacturers."

PSL 5.1.4 Depths and cover

Add the following to Subclause 5.1.4.3:

"The minimum clearances at crossings between the barrels of proposed pipelines or between existing and proposed pipelines shall be 300 mm. The pipeline shall be laid horizontally at this level for a distance of at least 1,0 m on either side of the centreline of the service crossed. The Contractor shall inform the Engineer should he find that this minimum clearance cannot be achieved."

Add the following new Subclause 5.1.4.6:

"The water pipelines shall be laid to the invert levels and gradients shown on the drawings and so that the minimum cover to the top of the pipe barrel from finished surface level is 1.0 m."

PSL 5.2 JOINTING METHODS

Add the following new Subclause

"PSL 5.2.5 HDPE Welding

Add the following:

"The HDPE pipes and specials shall be joined by means of butt fusion using approved, butt welding equipment and fully accredited, trained plastic welders in accordance with the manufacturer's code of practice. The Contractor shall undertake the following steps prior to the commencement of welding on site:

a) Provide welding tables applicable specifically to pipe diameters to be welded and the welding equipment used.

b) Provide a certificate of calibration for the welding machine to be used. The certificate shall bear the model number of the welding machine, the name and the address of the certifying agent, the date of the test and a statement as to the accuracy of the temperature and pressure gauges on the machine in question.

c) A certificate of calibration dated more than 12-months from the Commencement Date is not acceptable.

d) Provide certification that the welder/operator has successfully completed an approved training course and is qualified to weld the sizes and classes of HDPE pipe to be used on this Contract.

e) A test weld is to be undertaken on site in the presence of the Engineer's Representative for approval prior to the commencement of welding the pipes. A test weld shall also be submitted to an approved laboratory to test the tensile strength of the butt fusion joint in accordance with SANS ISO 4427.

Under no circumstances will welding be permitted to commence prior to the provisions of the above mentioned certificates and the weld test, and the cost of delays resulting from failure to timeously undertake the abovementioned steps shall be borne by the Contractor.

Each joint is to be uniquely numbered. Once welding of a joint has been completed, the details of the weld shall be logged and the information forwarded to the Engineer."

PSL 5.5 ANCHOR/THRUST BLOCKS AND PEDESTALS

Add the following:

"Thrust blocks are required for all bends where flexible joints are used. These thrust blocks are not necessarily required for pipelines that are continuously welded or where locked joints are used.

Where locked joints are used in lieu of thrust blocks, the Contractor shall submit to the Engineer the relevant calculations of the anchored lengths for all relevant bends.

The concrete in the thrust blocks shall be at least Grade 25 MPa/20. The minimum cover to the steel shall be 50 mm. Where no reinforcement is shown allow 100 kg/m³ of concrete."

Add the following new subclauses to Clause 5:

"PSL 5.11 WORK ON EXISTING PIPELINES

The Contractor is required to connect to the existing water reticulation network.

The Contractor shall ensure that all new pipes, specials and other items, together with any fittings or other items affected by the work are available on site prior to commencing the connection. No work shall be permitted without the prior approval of the Employer.

PSL 5.12 END CAPS

The Contractor shall, at the end of each day's work, fit end caps to the open ends of the pipeline under construction. The end caps shall be manufactured in such a manner that it can be fitted to seal off the pipeline to the extent that it is totally dust and water proof. The end cap must be able to withstand a pressure of 5 m head of water externally when fitted.

End caps shall be maintained during nonworking periods.

The tendered rates for the laying of pipe shall be deemed to include for the supply, fitment, and maintenance of the end caps."

PSL 6 TOLERANCES

No amendments.

PSL 7 TESTING

PSL 7.3 STANDARD HYDRAULIC PIPE TEST

PSL 7.3.1 Test pressure and time of test

PSL 7.3.1.2: The maximum working pressure for the different pipes is indicated by the class of the pipe. The field test pressure shall be the pipe`s pressure rating measured at the lowest point on the section to be tested.

PSL 8 MEASUREMENT AND PAYMENT

PSL 8.1 GENERAL

Add the following:

"The supply of all pipes will be measured as specified in Subclause 8.2.1.

No extra payment will be made for any cutting, etc., required for permanent closure pipes or for the creation of flexible connections at structures.

No extra payment will be made for testing nor for temporary water supply connections, temporary thrust blocks, blank flanges and plugs for testing, which will be held to be included in the price for the laying of pipes, valves and specials."

PSL 8.2.1 Supply, lay and bed pipes complete with couplings

Add the following:

“The rates for supplying, laying and bedding pipes shall also cover the cost of testing in short sections.

The rate for supplying, laying and bedding of the pipes shall also cover the cost of cleaning the pipes as specified in Subclause 5.10 and for marking of the items.”

PSL 8.2.2 Extra-over 8.2.1 for the supplying, laying and bedding of specials complete with couplings

Add the following:

“Tees

Specials will be measured by number, extra over the cost of the installation of pipes.

The tendered rate shall include the supply, lay, bedding, jointing and testing of the specials.

The tendered rate for specials shall be held to include machined collars on the specials and the couplings/welds necessary to fit the special to the associated pipeline and one set of bolts, nuts and gaskets per flanged special.

Bends

Bends will be measured by number, extra over the cost of the installation of pipes.

The tendered rate shall include the supply, lay, bedding, jointing and testing of the bends

The tendered rate shall also include the cutting of pipes and preparation of pipe ends.

No extra over payment will be made for bends smaller than 5°. The cost for bends or angular deviations at flexible couplings shall be deemed to be included in the tendered rate for the supply, lay, bedding, jointing and testing of pipes.”

PSL 8.2.11 Anchor blocks/Thrust blocks and pedestals.

*Insert "*concrete*" before "*and*" in the last line of the last paragraph.*

Add the following:

The rates tendered for thrust blocks shall cover the cost of excavation and backfill, concrete, formwork, and steel reinforcement (including 0,1 t high tensile steel per cubic metre of concrete where the amount of steel is not indicated on the drawings) as well as labour, etc., to complete the thrust blocks as shown on the drawings in addition to the operations and materials specified in Subclause 8.2.11."

TABLE OF CONTENTS

Page

PSLB 1 SCOPE

No amendments.

PSLB 2 INTERPRETATIONS

PSLB 2.3 DEFINITIONS

In the subclause entitled "Main fill" *delete* "150 mm" *in second line and substitute* "300 mm".

Add new definition:

Stiffness ratio.

FModulus of soil reaction of the bedding material.

PSLB 3 MATERIALS

PSLB 3.1 SELECTED GRANULAR MATERIAL

For bedding material for pipes see Subclause 3.3 below.

In the second line delete "19 mm" *and substitute* "10 mm".

Add to the subclause:

"The maximum compactibility factor shall be 0,4."

PSLB 3.2 SELECTED FILL MATERIAL

Replace this subclause with the following:

"All material up to the underside of backfill shall be measured as selected granular. For bedding material as Subclause 3.3 below."

PSLB 3.3 BEDDING

Add to the subclause:

"Bedding (selected granular and selected fill material) for pipes shall be fine sand or fine non-cohesive soil, carefully selected, with maximum particle size of 5 mm and which shall not cake nor form lumps when drying. Samples of bedding sand shall be submitted by the Contractor to the Engineer for approval well in advance of construction. Only after the Contractor has received written approval from the Engineer, may he/she proceed with placing sand as selected granular material.

No sharp-edged stones shall be allowed to come into contact with the pipes or fittings. Joint holes (pockets) shall be provided in the trench bottom and bedding, at each pipe joint to facilitate welding, and no extra payment will be made for forming or filling the joint holes (pockets) with bedding sand.

All bedding material used for the cradle beneath and surrounding the coated steel pipes shall comply with the following requirements:

GRADING ANALYSIS RANGE	
SIEVE SIZE (mm)	PERCENTAGE PASSING
6,7	98 to 100
4,76	85 to 100
2,36	55 to 95
1,18	30 to 75
0,60	20 to 50
0,425	16 to 38
0,30	13 to 27
0,15	5 to 18
0,075	0 to 12

The material shall be free of organic matter and shall have a compactibility factor of not more than 0.4. The material should be classified as silty to fine sand having a stiffness ratio of not less than 6,0 MPa. Furthermore, the origin of the materials should, preferably, be river transported since it is preferable that the larger grains (3,0 to 4,8 mm in size) be rounded and not sharp and angular.

The Contractor will be required to carry out his/her own quality control testing of the material to ensure that it meets the bedding sand requirements and complies with this specification at all times. At least one grading analysis shall be carried out for every 100 lineal metres of bedding placed. The results of these tests shall be forwarded to the Engineer within 24 hours of completion of the test. Should the material not comply with the specification, the Contractor shall remove and replace it with approved material at his/her own cost.

Depending on the actual material supplied by the Contractor, the moisture content may be critical to enable satisfactory placing and compaction and the Contractor will be deemed to have allowed in his tendered rate for any and all adjustments required to the moisture content of the bedding material at all times.

Where structures are to be built over pipework, where shown on the drawings, or where ordered by the Engineer, the bedding cradle specified shall be stabilized with 5% cement as specified under subclause PSLB 3.5.

No extra payment will be made for forming or filling joint holes (pockets).”

PSLB 3.4 SELECTION

PSLB 3.4.1 Suitable material available from trench excavation

Add to the subclause:

"If, in the opinion of the Engineer, bedding material can be produced from the excavated material, the Contractor shall, if so ordered by the Engineer, screen or otherwise treat (as scheduled) the excavated material in order to produce material suitable for bedding (see also Subclause 8.2.1 below)."

PSLB 4 PLANT

No amendments.

PSLB 5 CONSTRUCTION

PSLB 5.1 GENERAL

PSLB 5.1.2 Details of bedding

Delete and replace with:

"Pipes shall be bedded and protected in accordance with the details shown in the Drawings."

Add the following subclause to Subclause 5.1.2:

"PSLB 5.1.2.1 Stone drainage layer beneath bedding

Stone shall be placed beneath the bedding layer to act as a drainage channel for excessive groundwater as shown in the Drawings. This layer shall be wrapped in geofabric and provided with outlet pipes if and where indicated by the Engineer"

PSLB 5.1.4 Compacting

*Replace "*90%" *with: "*93% (100% for sand)".

Add to Subclause 5.1.4:

"Steps will have to be taken by the Contractor to ensure that flexible pipes do not deform excessively in cross-section during and after construction and backfilling operations. The maximum deflection which will be acceptable at any stage during or after construction is 2% of the pipe diameter horizontally or vertically. The Contractor will be required to provide the necessary apparatus and to monitor deflection during construction.

Pipe deformations will only be maintained within the specified tolerances by correct backfilling practice. No heavy compaction equipment will be permitted for compaction of any pipe bedding, only pneumatic or hand rammers being acceptable. To this end, and to achieve the 93% compaction specified it is required that the bedding material be brought up evenly on either side of the pipe. The use of complete saturation of the material as a method of achieving the specified compaction may, subject to the Engineer's approval, be used. However, in this regard, Tenderers are advised that the presence of excessive quantities of water in the pipe trench could lead to flotation of the pipe.

Prior to the commencement of pipe laying the Contractor will be required to submit, to the Engineer, for his approval, his proposed methods of placing, and compacting methods which he proposes to implement in order to ensure compliance with the specification."

Add the following Subclause:

"PSLB 5.1.5 Testing

Pipe joints and pipe fittings shall be left exposed with a minimum of 300 mm clearance around the bottom of the pipe during hydraulic pressure testing of the pipe to facilitate inspection."

PSLB 5.3 PLACING AND COMPACTING FLEXIBLE PIPES

a) Bedding cradle

Delete the subclause and substitute the following:

"The pipes shall be bedded on a minimum 100 mm thick layer of compacted granular bedding material on which a 50 mm thick layer of uncompacted granular bedding material has been placed and spread. Loose granular bedding material lying next to the pipe shall be placed into the haunch area and compacted with suitable hand tools (covered with rubber to prevent damage to the pipe coating), and additional selected granular material shall be added and compacted in layers up to the mid-point of the pipe diameter in the vertical plane. The remainder of the bedding i.e. the selected fill blanket, shall be placed in layers up the sides of the pipe, each layer being compacted until a level of 300 mm above the crown of the pipe is reached.

All joint (fox) holes shall be filled with bedding material."

b) 200 mm Selected fill blanket

Delete "200 mm" *from title*.

PSLB 6 TOLERANCES

PSLB 6.1 MOISTURE CONTENT AND DENSITY

Add to the subclause:

"The permissible deviations applicable are to be those for Degree of Accuracy II class of work."

PSLB 7 TESTING

No amendments.

PSLB 8 MEASUREMENT AND PAYMENT

PSLB 8.1 PRINCIPLES

PSLB 8.1.3 Volume of bedding materials

Add to the subclause:

"(c) The volume of bedding material shall be measured net, excluding the volume of the pipe is to be deducted.

(d) No additional payment will be made for bedding material placed in joint (fox) holes.

(e) The rate for bedding and backfill material from insitu material shall include the selection and sieving of the material."

PSLB 8.1.5 Disposal of displaced material

Replace the contents of this subclause with the following:

"Material displaced by the pipeline and by imported material from sources other than trench excavation, shall be disposed of at an approved site furnished by the Contractor. No haulage is payable for such material."

PSLB 8.1.6 Freehaul

*Delete the words "*of 0.5 km" *in the first line of the subclause*:

PSLB 8.2 SCHEDULED ITEMS

PSLB 8.2.1 Provision of bedding from trench excavation

Delete the subclause and substitute the following:

"a) Selected granular material.. Unit : m^3

i) <u>Without the need for screening</u>:

The rates shall cover the cost of acquiring, from any point along the trench excavation as may be selected by the Engineer, bedding that complies with the relevant requirements of the specification, of delivering it to points alongside the trench spaced to suit the Contractor's methods of working, of making good any backfill deficiency from points where backfill has been acquired, and of disposing of displaced material.

ii) <u>Including for screening</u>:

The rates shall cover the cost of screening or otherwise treating excavated material, at any point along the trench excavation as may be selected by the Engineer, in order to produce bedding that complies with the relevant specification, delivering it to points alongside the trench, spaced to suit the Contractor's methods of working, of making good any backfill deficiency there may be from points where screened backfill material has been acquired, and of disposing of displaced material."

PSLB 8.2.2.1 Supply only of bedding by importation

Delete the Subclause 8.2.2.1 and substitute the following:

"Including for screening and/or other treatment:

a) Selected granular material.. Unit : m^3

b) Bedding sand to specified bedding dimensions .... Unit : m^3

The rates shall cover the cost of acquiring, loading, transporting, offloading, screening or otherwise treating excavated material in order to produce bedding that complies with the relevant specification, delivering it to points alongside the trench spaced to suit the Contractor's methods of working and of disposing of displaced material.

NOTE: The rate for the supply and laying of pipelines covers the cost of handling the bedding material from alongside the trench, placing it under the pipeline, forming joint holes and completing the bedding around and over the pipeline."

PSLB 8.2.2.3 From commercial sources

*Delete the words "*of 0.5 km" *in the last line of the subclause*:

PSLB 8.2.3 Concrete bedding cradle

Add the following paragraph to the subclause:

"All concrete bedding to pipes will require formwork. The rate for concrete bedding shall include for the supply, installation and stripping of all formwork."

PSLB 8.2.4 Encasing of pipes in concrete

Delete the fifth and sixth lines and substitute the following:

"encasing the pipe in concrete 200 mm thick each side of the pipe and to 2000mm above the crown of the pipe including the cost of formwork, (if any), etc. and the cost of formwork to form stop ends on either side of collars, couplings, joints etc. if instructed by the Engineer.

The rate for concrete encasing shall include for the supply, installation and stripping of all formwork."

Add the following Subclauses:

"PSLB 8.2.6 Extra over items 8.2.1 and 8.2.2 for bedding stabilised with 5% cement.......... **Unit : m^3**

The tendered rate shall include full compensation for selecting, mixing, backfilling and compacting the stabilised material to 90% of modified AASHTO density."

PSLB 8.2.7 Provision of stone/geofabric to deal with water (Provisional) .... Unit : m³

If in the opinion of the Engineer, the Contractor complied with the requirements for dealing with water as specified in PSA 8.8.7 of the SANS 1200 A amendments., the Engineer may instruct the installation of crushed stone and filter fabric. Payment for these items will only be made where instruction was given in writing by the Engineer.

The provision of crushed stone bedding material will be measured by volume based on the Drawings

The unit rate shall cover the cost of supplying and laying the crushed stone.

The filter fabric will be measured separately by area based on the specified trench width, the stone bedding thickness and an overlap of 300 mm.

The rate shall cover the cost of the supply, delivery and laying of the filter fabric."

TABLE OF CONTENTS

Page

PSLC 1 SCOPE

No amendments.

PSLC 2 INTERPRETATIONS

No amendments.

PSLC 3 MATERIALS

PSLC 3.1 DUCTS

Electrical ducts shall be 63 mm diameter HDPE and 110 mm or 160 mm diameter unplasticized PVC sewer pipes, normal service, in accordance with SANS 791 and shall be supplied by the Contractor complete with end caps and draw wires.

Fibre optic ducts shall be 32 mm diameter HDPE fibre optic duct

PSLC 4 PLANT

No amendments.

PSLC 5 CONSTRUCTION

No amendments.

PSLC 6 TOLERANCES

No amendments.

PSLC 7 TESTING

No amendments.

PSLC 8 MEASUREMENT AND PAYMENT

PSLC 8.1 GENERAL

Add the following:

"The sealing and marking of ducts and draw pits/manholes will not be measured and paid separately. Notwithstanding Subclause 8.2.5 and 8.2.7, the rate tendered for laying of ducts and draw pits/manholes shall also include for all costs involved in sealing, marking duct ends, draw pits/manholes and the re-excavation and backfilling for marking purposes."

TABLE OF CONTENTS

Page

PSLD 1 SCOPE

No amendments.

PSLD 2 INTERPRETATION

No amendments.

PSLD 3 MATERIALS

PSLD 3.5 MANHOLES, CHAMBERS, ETC

PSLD 3.5.2 Precast concrete sections

Add the following:

"Sectional spun-concrete cylinders shall be manufactured from dolomitic aggregate. Dolomitic aggregate and dolomitic sand shall be used for all concrete, mortar, benching and plaster used in manholes."

PSLD 3.5.7 Step irons

Delete the contents of this subclause and substitute with the following:

"Step irons shall be of the copolymer polypropylene type with a 12 mm dia. high tensile steel reinforced core and shall be of length suitable for fixing in brick, precast concrete or reinforced fibre cement as applicable."

PSLD 4 PLANT

No amendments.

PSLD 5 CONSTRUCTION

PSLD 5.5.5 Precast concrete sections

Add the following:

“Precast concrete chamber sections shall be so placed that the inside surfaces of the completed manholes will be truly aligned.

The joints between successive precast concrete rings shall be sealed with Cemflex or similar approved.

PSLD 6 TOLERANCES

No amendments.

PSLD 7 TESTING

PSLD 7.2 TESTS AND ACCEPTANCE/REJECTION CRITERIA

PSLD 7.2.6 Watertightness of manholes

Add the following:

"Manholes will be inspected at the end of the after completion. No ingress of groundwater into the manhole will be allowed.

Should any manhole fail to pass the inspection to the satisfaction of the Engineer, the fault or faults shall be made good by the Contractor at his own expense according to methods approved by the Engineer and the work shall be inspected again. The cost of all extra work and inspection shall be borne by the Contractor."

PSLD 8 MEASUREMENT AND PAYMENT

No amendments.

TABLE OF CONTENTS

Page

PSLE 1 SCOPE

No amendments.

PSLE 2 INTERPRETATION

No amendments.

PSLE 3 MATERIALS

PSLE 3.1 CULVERT UNITS AND PIPES

d) Skewed ends

Add the following:

"Skewed ends for pipe culverts may be cut on Site."

PSLE 3.4 MANHOLES, CATCHPITS, AND ACCESSORIES

PSLE 3.4.1 Bricks

Add the following:

"Bricks shall be engineering bricks complying with the requirements of SANS 227."

Add the following subclause:

"PSLE 3.6 MATERIALS FOR SUBSURFACE DRAINS

a) Pipes and fittings

Pipes for subsurface drains shall be normal duty, perforated or slotted uPVC pipes complying with SANS 791. Fittings shall be heavy duty and shall also comply with SANS 791.

The size of the perforations in perforated pipes shall in all cases be 8 mm in diameter ± 1,5 mm, and the number of perforations per metre shall not be less than 26 for 100 mm pipes and 52 for 150 mm pipes. Perforations shall be spaced in two rows for 100 mm pipes and in four rows for 150 mm pipes.

Slotted pipes shall have a slot width of 8 mm with a tolerance of 1,5 mm in width. The arrangement of the slots is subject to the Engineer's approval, but the total slot area shall not be smaller than that specified for perforations.

b) Crushed stone

Crushed stone shall be 19 mm single-sized and shall comply with the requirements of SANS 1083.

c) Geotextiles

Refer to Subclause 3.1.3 of SANS 1200 DK and amendments”

PSLE 4 PLANT

No amendments.

PSLE 5 CONSTRUCTION

Add the following new subclause:

“PSLE 5.8 SUBSURFACE DRAINS

Subsurface drains shall be constructed where shown on the Drawings or as ordered by the Engineer.

The Contractor shall connect the subsurface drains into the stormwater system at manholes or catchpits by means of 110mm diameter unperforated PVC pipes.”

PSLE 5.9 BACKFILLING AROUND STRUCTURES

Material adjacent to the walls of the manholes must be watered and mixed to its optimum moisture content, and compacted in layers not exceeding 150 mm in the compacted state. Compaction must be minimum 100% MOD AASHTO for non-cohesive material, and minimum 93% of MOD AASHTO density for cohesive materials.

Backfilling around the structure must be carried out in even layers to avoid uneven side forces.”

PSLE 6 TOLERANCES

No amendments.

PSLE 7 TESTING FOR LEAKAGE

No amendments.

PSLE 8 MEASUREMENT AND PAYMENT

PSLE 8.2 SCHEDULED ITEMS

PSLE 8.2.8 Supply and installation of manholes, catchpits and the like

Replace the contents of the item with the following:

"Separate items are listed for manholes and catchpits etc. with reference to depths (as shown the Drawings or scheduled in the Bill of Quantities) and type. The rate shall cover the cost of any excavation in all material (including disposal of surplus) and backfilling, additional to what is measured under the relevant pipe trench item (refer to SANS 1200 DB 8.2.2 and 8.2.3). The rate shall further cover the cost for building the manholes and catchpits complete as shown on the relevant drawings, including step irons, cover and frames (Type 2A unless otherwise shown on the drawings), benching, vents, brickwork, concrete work, grids, other accessories, and the building in of pipework, along with all materials, plant and labour.

The depth category of manholes and catchpits shall be measured as the difference between the cover level and the deepest invert level."

Add the following new subclause:

"PSLE 8.2.14 Subsurface drains

Depending on the conditions where subsurface drains are to be constructed, they will be scheduled and measured, at the discretion of the Engineer, **either** by individual items for excavation and for the supply and installation of the materials required for the drains, **or** by a single rate per metre length of drain constructed.

Where a single rate per metre length is scheduled, the tendered rate shall cover the cost of excavation, disposal of surplus material, supply of all material, labour, plant and incidentals to complete the construction of the subsurface drain as shown on the Drawings.

PSLE 8.2.15 Supply and install rodding eye for subsurface drains

Rodding eyes will be schedules and measured as individual items. The rate shall cover all costs for the supply and installation of the complete rodding eye as per the detail drawings, including cap, mass concrete encasements and pipes & bends connecting rodding eye to subsoil pipe."

TABLE OF CONTENTS

Page

PSLG 2 INTERPRETATIONS

PSLG 2.1 SUPPORTING SPECIFICATIONS

Delete from sub clause 2.1(b), "or SANS 1200 AA, as applicable" *and throughout the specification delete all reference to SANS 1200 AA*.

Delete from sub clause 2.1(c), "or SANS 1200 DA, as applicable" *and throughout the specification delete all reference to SANS 1200 DA.*

Delete from sub clause 2.1(e), "or SANS 1200 GA, as applicable" *and throughout the specification delete all reference to SANS 1200 GA.*

Add the following:

"h) Horizontal Directional Drilling Good Practice Guidelines Draft, as published by the South African Society for Trenchless Technology (SASTT)"

PSLG 2.3 DEFINITIONS

Add to the sub clause:

"The Works shall mean all the features making up the entire jacking operation including construction of both jacking (thrust) and receiving pits as well as the excavation placing and jacking of the pipes together with all support activities.

Pipe ramming. The installation of steel casing pipes by driving/hammering into position. The material within the steel pipe sleeve is then removed, via the pipe, by hydraulic or mechanical methods. The permanent pipe or cable is then installed inside the steel sleeve.

Horizontal boring. The installation of pipes and cables on a constant grade and alignment, by pulling them into position behind a hydraulically or pneumatically powered cutting or hammer head. The material displaced by the head is either displaced sideways or removed, via the pipe, by hydraulic or mechanical methods.

Directional drilling. The installation of pipes and cables on a variable grade and alignment, by pulling them into position behind a hydraulically or pneumatically powered traceable and steerable cutting or hammer head. The material displaced by the pipe is either displaced sideways or removed, via the pipe, by hydraulic or mechanical methods.

Pipe jacking. The installation of large diameter pipes by pushing the pipe into position whilst excavating ahead of the pipe by hand or mechanical method."

PSLG 3 MATERIAL

PSLG 3.1 PIPES

Delete the sub clause and substitute with the following:

"Pipes for jacking shall be SI Type reinforced concrete manufactured in accordance with SANS 677 to the D load specified on the drawings. All pipe joints shall be in-the-wall joints with a cast in steel band that provides a watertight seal. The actual diameters of the pipes shall not be less than the nominal diameters given on the drawings or stated in the schedule.

In addition to withstanding the specified two (or three), edge bearing test-load, the pipes shall be capable of withstanding, without damage during jacking, the maximum longitudinal force to be transmitted by the Contractor's jacks and method of installation.

The details of the pipes to incorporate the jacking shield and interjack stations shall be determined by the Contractor to suit the proposed method of construction. The pipe class of these pipes shall not be less than the class of pipe or type of pipe stated on the drawings or determined by the Engineer. The Contractor must adhere to the joint sealing details given in PSLG 3.1.2 below.

At least one hole shall be formed in the crown of each 2.4m long pipe to allow for the injection of both a lubricant, if required, and a final grout. The final layout of grout holes is the Contractor's responsibility.

The Contractor must ensure that the pipes shown on the drawings and mentioned in the documents can be jacked the full distance shown on the drawings.

The jacking pipe shall be manufactured with a HDPE anchor knob lining extending for 270 degrees of the pipe barrel.

Add the following sub clauses:

"PSLG 3.1.1 Intermediate jacking pipes

Add the following:

In circumstances where it is necessary or desirable to use interjack stations, jacking pipes between manholes or junctions, the number and type of such intermediate jacking pipes is to be determined by the Contractor. The joint between pairs of intermediate jacking pipes shall be protected externally by a cylindrical mild steel sleeve of wall thickness at least 8mm, which shall overlap the pipes on either side of the joint for a distance of at least 150mm. The final joint is to include a substantial and permanent caulked seal within the joint."

PSLG 3.1.2 Joints and seals

It is the Contractor's choice as to type of joint used in the pipes to be jacked. However, applied forces used to jack the pipes must be uniformly distributed around the joint to avoid damaging the joint. Pipes that are delivered to site with damaged joints must be rejected by the Contractor.

A seal is required at each joint to minimise ingress of water. Ingress of water into a jacked section of pipes stemming from the joints shall not exceed 5 litres per minute in total. The chipboard packing used to distribute stresses on the joints should be raked out to a depth of 25mm on the inside all round and sealed with a durable flexible sealing agent such as bituseal, thioflex or similar."

PSLG 3.2 INTERMEDIATE JACKING STATIONS

Delete the sub clause

PSLG 5 CONSTRUCTION

PSLG 5.1 GENERAL

PSLG 5.1.1 Authority to jack pipelines under facilities controlled by Third Parties

Add the following:

"The Employer will obtain permission from the relevant authorities for jacking under roads. However, the Contractor is to confirm that such permission has been granted at least 14 working days before commencing work."

PSLG 5.1.2 Competence

Add to the sub clause

"Jacking and excavation shall be supervised and undertaken by persons fully conversant with this work. (Clause 4.11 and 4.12 of the GCC 2015)."

PSLG 5.1.3 Design calculations by Contractor

Add to the sub clause:

"The Contractor shall for each crossing supply the following information to the Engineer within 14 days of receipt of the Letter of Acceptance:

a) All the necessary sleeve pipe characteristic details i.e. class etc.
b) The maximum jacking forces that can be applied during the jacking operation.
c) Full design details and calculations which must include expected loads pertaining to the sleeve sections he proposes to use, where protection to the sleeve pipe is required, full details including referenced design details which must be generally in accordance with SANS 10102-1 and 10102-2 and drawings etc., must be included.
d) Details of calculations and drawings of the proposed method of load transfer from the pipe to the thrust pit wall.
e) The proposed method of working - i.e. the position of the thrust and reception pits, size and number of jacking points he intends using.
f) Full details of the joint sealers, sleeves and methods of lubrication and grouting to be employed.
g) Full details and sketches of the proposed method to be used to seal the joints at intermediate jacking stations, if applicable.
h) Full details of stabilising unstable areas and grouting of voids.

The design calculations and drawings shall be signed by a Registered Professional Civil Engineer responsible for the designs.

The Contractor shall not commence any pipe jacking work shown on the drawings or specified in the specifications until the Engineer has authorised in writing that the work may proceed."

PSLG 5.1.4 Contractor solely responsible

Add to the sub clause:

"No approval of any material or plant and its operation, or of any construction procedure to be used will imply any relaxation of the requirements governing the quality of the materials or of the finished work or relieve the Contractor of his/her responsibilities under the Contract."

PSLG 5.2 SAFETY CONTROL REQUIREMENTS

PSLG 5.2.3 Recording movements

PSLG 5.2.3.1 General

Delete the sub clause and substitute with the following sub clause:

"The Contractor shall take movement measurements correct to 1,0 mm of accuracy of any change in the line and level of road before the start of the Contract and at such intervals as directed by the Engineer for a period up to 12 months after issue of the Completion Certificate. However, no more than 15 sets of reading will be required in this period. A copy of these measurement records shall be made available to the Engineer. The cost of this work is deemed to be included in the tendered rates."

PSLG 5.2.3.2 Working under roadways

Add to the sub clause:

"The Contractor shall bear full responsibility for any consequential damage to persons and property resulting from subsidence."

PSLG 5.4 EXCAVATION

PSLG 5.4.1 General

Add to the sub clause:

Except as required in terms of 5.2.5 SANS 1200 LG 1983, the provisions of SANS 1200 D shall apply.

PSLG 5.4.2 Thrust pits

In the second paragraph, delete the words "Factories, Machinery and Building Work Act, 1941 (Act 22 of 1941)" *and replace with the words* "Occupational Health and Safety Act 1995".

Add to the sub clause:

Claims arising out of any accidents or incidents in or adjacent to these access pits will not be considered by the Employer.

Stormwater control measures around these pits are also necessary to prevent water ingress into the pits. Provision must be made by the Contractor to keep these pits free of seepage and stormwater.

Thrust pits will in general only be permitted at positions indicated on the drawings or where manholes or junctions are required or as agreed on Site by between the Contractor and the Engineer. Jacking pits shall be of sufficient size to accommodate the jacking operation and any manhole structure to be constructed upon completion of the jacking. The approximate dimensions of the pits shall be agreed with the Engineer before work commences. The Contractor will be required to design and construct all thrust blocks, bases and other temporary works required to maintain the stability of the pits and shall demolish and remove these upon completion of the jacking operation and the Contractor shall take into account all such limiting factors when preparing his/her tender.

PSLG 5.4.3 Jacking of pipeline

PSLG 5.4.3.1 General

Add to the sub clause:

A lead pipe with a rebated front end over which the trailing end of the shield is fitted should be the first concrete pipe used. This should minimise overbreak. No material may be removed in advance of the leading edge of the shield in unstable or loose materials.

As the pipe is advanced, excavation is to take place within the shield attached to the lead pipe under the full-time supervision of a responsible foreman to ensure that the end of the shield is always fully plugged with earth at a safe angle of repose within the pipe. The Contractor shall ensure that there is not uncontrolled flow of sand, mud or earth into the pipe which could result in imperilling excavation personnel or the formation of cavities above or around the sleeve pipe. If at any stage during the jacking operation such conditions arise the Contractor shall immediately plug the pipe and stabilise the material before proceeding with further work.

Should it be necessary, the Contractor shall allow for stabilising the soil by dewatering, chemical grouting, or any other approved means. The design of the shield shall be such as to permit the face to be completely or partially closed by boarding or similar to control material flow from the face.

During weekend or holiday stoppages the Contractor must make sure that a plug of soil is left in the shield.

Add to the sub clause:

"PSLG 5.4.3.6 Continuous jacking

In order to minimize problems due to the build-up of skin friction on a static pipe, the pipes are to be jacked continuously unless agreed to otherwise with the Engineer. Adequate lighting shall be provided by the Contractor at night.

PSLG 5.5 JACKING PROCEDURE

PSLG 5.5.1 Procedure

Add to the sub clause:

Each jack shall be fitted with a pressure gauge suitably calibrated such that the actual jacking forces can be read at any time.

Suitable packing of hard material shall be attached to the concrete face at the trailing vertical ends of the pipes in order to transfer the jacking force. The packing shall constitute a complete circle and be sufficiently wide to transfer the applied load.

A suitable steerable shield is to be fitted to the front of the lead pipe. The shield is to incorporate a cutting edge which can be controlled by jacks to maintain the pipe on line and level.

Pipe jacking is generally carried out up-grade. The Contractor may choose to do otherwise. This will be subject to the approval of the Engineer. Provision must be made by the Contractor for the necessary drainage required.

PSLG 5.5.2 Lubrication of structure during jacking

Add to the sub clause:

To ease pipe friction, the Contractor shall make provision for the injection of bentonite or other approved lubricant.

PSLG 5.6 BACKFILLING AND DISPOSAL OF EXCAVATED MATERIAL

Add the following sub clause:

"PSLG 5.6.1 Backfilling

Both thrust and reception pits must be backfilled using the removed material. Backfill compaction rates must not be less than 90% Modified AASHTO with the top 1,5 m of backfill being compacted to a minimum 93% Modified AASHTO. The backfill must be built up to at least 500 mm above the natural ground level to prevent stormwater pounding around the excavation pits."

Add the following sub clauses:

PSLG 5.7 GROUTING AND PLUGGING

Add to the sub clause:

In soft material the grout shall consist of cement/bentonite with a compressive strength of 5MPa at 28 days. In hard material and rock the grout shall consist of cement/sand with a compressive strength of 25 MPa at 28 days.

Add the following sub clause:

"PSLG 5.9 MARKERS

On completion of the backfill the Contractor must place a concrete marker post (prestressed lintel) into the ground directly above the centre line of the pipe at each end of the pipe-jack sleeve.

PSLG 5.10 REMEDIAL MEASURES

All remedial measures will be carried out and completed to the standards set by the various controlling authorities.

Roads – remedial measures plus time related professional costs needed to reinstate roads and fill embankments will be the Contractor's liability.

Remedial measures are those relating to the need to put right settlement and movement of road surfaces, formation layers or fill embankments including providing all road safety markers, traffic control, or signs and all associated needs of the road authority to allow remedial work to proceed without danger to workers or traffic. The Contractor must arrange all matters regarding remedial work with the road authority. In most instances these measures will comprise jacking up concrete roads using grout and re-grading to original elevation formation layers and premix surfacing as well as mending drainage fixtures where these have been damaged. All the remedial work will be directed by the Engineer to his satisfaction and approval.

PSLG 5.11 RECORD DRAWINGS

The Certificate of Completion will not be issued until the Contractor has supplied to the Engineer, A1 size drawings showing details of the completed jacked pipeline. Each such drawing shall be certified by the Contractor to be an accurate reflection of the details of the work as constructed.

PSLG 5.12 BRICKING UP OF SLEEVE ENDS

Upon completion of the jacking, the Contractor shall brick up the sleeve ends to prevent ingress of sand."

PSLG 6 TOLERANCES

PSLG 6.2 PERMISSIBLE DEVIATIONS

In the first line delete "100 mm*" and substitute with* "50 mm".

PSLG 6.3 CHECKING ALIGNMENT

Add to the clause:

"A copy of the results of all checks together with a statement detailing corrective measures taken shall be available for inspection on Site at all times and further copies shall be submitted to the Engineer on a weekly basis."

Add the following sub clause:

"PSLG 6.4 MEASUREMENT

Throughout the jacking operation the Contractor is requested to take and record the following measurements.

a) A plot of pressure (kN/m²) and total force (kN) originating from the combined force of all hydraulic jacks used to move pipes versus accumulative length of jacked pipe. As soon as a lubricant is used it must be recorded on the plot. If heavy ground water seepage is noted this must also be recorded on the plot. A time scale in days should also be used in conjunction with jacked length of pipe. It is also important to record start up force required to move pipes after a delay, i.e. after weekend.

b) The dimensions of the thrust block used must be recorded as well as the accumulative thrust force on the block (kN) together with any movement of the thrust block (mm).

PSLG 8 MEASUREMENT AND PAYMENT

PSLG 8.2 SCHEDULED ITEMS

PSLG 8.2.2 Supply of pipes to be jacked

Add the following sub clause:

The unit of measurement for supply of pipes to be jacked shall be the metre of pipe and will be measured between ends of the completed pipeline. The measurement shall include intermediate jacking pipes.

The rate shall cover the cost of supplying selected pipes with grouting holes, delivering, handling, storing of pipes, rubber rings, packing pieces and flexible sealing to joints between intermediate jacking pipes.

PSLG 8.2.3 Jacking of pipes

In the first paragraph add the word "Grouting" *before the words*" sealing grouting holes..."

PSLG 8.2.6 Supply and install pipes by pipe jacking method, complete with excavations

The rate shall cover the cost of all activities specified in Sub clauses 8.2.2, 8.2.3 & 8.2.4 of SANS 1200 LG.

Add to the sub clause:

"The rate shall include for grouting all voids around the pipe annulus which are a result of the pipe jacking operation."

PSLG 8.2.9 Stabilisation of unstable areas or grouting of voids where ordered

Delete the clause.

PSLG 8.2.10 Standing time for pipe jacking gang and the jacking equipment

In the first paragraph, delete the words "Wage Act, 1957 (Act 5 of 1957)" *and replace with the words* "Basic Conditions of Employment Act No. 75 of 1997".

Add to the sub clause:

"PSLG 8.2.11 Recording of movements

The unit of measurement will be per visit and set of readings taken (PSLG 5.2.3 above).

The rate shall cover for all labour, equipment, as well as plotting up of the reading for presentation to the Engineer.

PSLG 8.2.12 Brick wall closure

The unit of measurement will be the number per jacked pipe diameter.

The rate shall cover all labour, materials and equipment used to construct the brickwork ends at each end of each jacked pipe after the installation of the steel water pipe through the sleeve.

The rate for foundations to brickwork walls shall be per cubic meter of concrete measured net as per design, including all excavation, formwork, backfill, etc to produce a complete foundation ready to receive the brickwork.

PSLG 8.2.13 Markers

The unit of measurement will be the linear meter of concrete lintel marker.

The rate shall cover all labour, equipment and paint to place the markers at the end of pipes."

TABLE OF CONTENTS

Page

PSME 1 SCOPE

No amendments.

PSME 2 INTERPRETATIONS

No amendments.

PSME 3 MATERIALS

PSME 3.2 PHYSICAL PROPERTIES

PSME 3.2.1 Subbase material

Replace the contents of paragraph (a) with the following:

"(a) The maximum particle dimension of the gravel shall not exceed 63 mm."

Replace the contents of paragraph (d) with the following:

"(d) The CBR at specified density shall be 45 for unstabilized material as well as for stabilized material prior to stabilization."

Delete paragraph (e).

PSME 3.2.2 Gravel shoulder and gravel wearing course material

Replace the contents of this subclause with the following:

"The material used for gravel shoulders and gravel wearing course shall comply with the following table:

PARAMETER	**GUIDELINE**
Maximum size (mm)	37.5
Oversize index (%)	< 5
Grading coefficient - *(note a)*	16 - 34
Shrinkage product - *(note b)*	100 - 365 *(note c)*
Strength (%) - *(note d)*	> 15
Hardness (treton impact value)	20 - 65

Notes:

(a) ([% passing 26.5mm sieve - % passing 2mm sieve] x % passing 4.75mm sieve) / 100

(b) Bar linear shrinkage x % passing

(c) Max 240 preferable to reduce dust levels

(d) Soaked CBR at 95% MOD AASHTO density

PSME 4 PLANT

No amendments.

PSME 5 CONSTRUCTION

PSME 5.2 EXCAVATION

PSME 5.2.2 Borrow pits

Insert the words "designated by the Engineer and" *between the words* "pits" *and* "established" *in the first line*.

PSME 5.7 TRANSPORT

Replace the contents of Subclause with the following:

"Refer to PSA 8.9 of SANS 1200 A amendments."

Add the following Subclauses:

"PSME 5.8 WEED KILLER

The subbase layer shall be treated before compaction by the application and mixing in granular HYVAR X or TENOC X weed killer in accordance with the manufacturer's instructions. An approved equivalent may be used.

PSME 5.9 INSECTICIDE

An approved insecticide shall be applied strictly in accordance with the manufacturer's instructions over the total area of the subbase. The instructions indicate whether the poison is to be applied before or after compaction of the layer."

PSME 6 TOLERANCES

No amendments.

PSME 7 TESTING

No amendments.

PSME 8 MEASUREMENT AND PAYMENT

PSME 8.1 BASIC PRINCIPLES

Insert a semicolon in the first line of paragraph (b) after the words "will be paid for once only" *and delete the rest of the paragraph*.

Amend paragraph (d) as follows:

"(d) that, in the case of material from a commercial source or from borrow pits selected by the Contractor, no additional payment will be made for the class of excavation, method of processing (except stabilizing), or overhaul."

PSME 8.3 SCHEDULED ITEMS

PSME 8.3.2 Construct the subbase course/shoulders/gravel wearing course with material from designated excavations

Replace the contents of Sub-item (a) with the following:

"The rate for (a) shall include full compensation for excavating and selecting subbase material, for loading and transporting the material, mixing-in or application of an approved weed killer and insecticide into the subbase and for either placing the material on the road or stockpiling the material for later use. When material is stockpiled, the rate shall include compensation for shaping and grading the stockpile so that it is free-draining."

PSME 8.3.3 Construct the subbase course/shoulders/gravel wearing course with material from commercial sources or designated borrow areas

Replace the heading of this item with the following:

"Construct the subbase course/shoulders/gravel wearing course with material from commercial sources"

Add the following paragraph:

"This item shall also apply to the construction of subbase course/shoulders/gravel wearing course with material from borrow pits selected by the Contractor. The tendered rate shall include the full cost supply, spreading and mixing-in or application of an approved weed killer and insecticide into the subbase."

PSME 8.3.9 Overhaul (haul exceeding 2 km):

Delete this item.

"No overhaul will be paid on material for the purposes of this Contract and all costs for transporting material must be included in the applicable tendered rates and amounts."

TABLE OF CONTENTS

Page

PSMF 1 SCOPE

No amendments.

PSMF 2 INTERPRETATIONS

No amendments.

PSMF 3 MATERIALS

PSMF 3.3 PHYSICAL AND CHEMICAL PROPERTIES

PSMF 3.3.1 Natural gravel (stabilized or unstabilized)

Replace the contents of paragraph (a) with the following:

"(a) The maximum particle dimension of the gravel shall not exceed 63 mm."

PSMF 4 PLANT

No amendments.

PSMF 5 CONSTRUCTION

PSMF 5.4 PLACEMENT AND COMPACTION OF A BASE OTHER THAN A WATER-BOUND MACADAM BASE

PSMF 5.4.4 Compaction

Replace “98% of modified AASHTO maximum density” *with* “102% of modified AASHTO maximum day density.”

PSMF 5.9 TRANSPORT

Replace the contents of this subclause with the following:

"All movement of material on this Contract will be considered as free-haul. No haulage cost will be paid."

PSMF 6 TOLERANCES

No amendments.

PSMF 7 TESTING

PSMF 7.3 ROUTINE INSPECTION AND TESTING

Replace Table 4 with the following:

"TABLE 4 - APPARENT DENSITY OF BASE

Specified apparent density %	Number of tests per lot	Minimum average density, %	Minimum value for any single test, %
86	4	86,1	82,7
	5	86,4	82,6
	6	86,5	82,4
	7	86,7	82,3
	8	86,8	82,2
	9	86,9	82,1

"

PSMF 8 MEASUREMENT AND PAYMENT

PSMF 8.3 SCHEDULED ITEMS

PSMF 8.3.3 Construct base with material from commercial sources or designated borrow areas

Replace the title of Item 8.3.3 with the following:

"**Construct base with material from commercial sources and compact**"

PSMF 8.3.8 Stabilizing agent

Replace the heading of this item with the following:

"**Road lime for modification**……………………………………………………………Unit: t"

PSMF 8.3.9 Overhaul

Delete this item.

"No overhaul will be paid on material for the purposes of this Contract and all the costs for transporting material must be included in the applicable tendered rates and amounts."

TABLE OF CONTENTS

Page

PSMJ 1 SCOPE

No amendments.

PSMJ 2 INTERPRETATION

No amendments.

PSMJ 3 MATERIALS

No amendments.

PSMJ 4 PLANT

No amendments.

PSMJ 5 CONSTRUCTION

PSMJ 5.2 EDGE RESTRAINTS

Add the following:

"Edge Restraints shall be constructed with expansion joints of width at least 12 mm at intervals not exceeding 10 m. These joints must be filled with a compound such as flexcell or similar approved product and sealed with a polysulphide sealant."

PSMJ 5.7 JOINT FILLING

Replace the last two paragraphs with the following:

"A mixture of sand that complies with SANS Subclause 3.3(b) and cement (Ratio 5:1) shall be broomed into the joints until they are full, and sufficient passes of a plate compactor shall be made to settle the joint filling. The procedure shall be repeated until the joints remain full after compaction.

All excess shall be washed off and care shall be taken not to contaminate the stormwater system. Damage caused during compaction shall be made good by the Contractor at his own expense."

PSMJ 6 TOLERANCES

No amendments.

PSMJ 7 TESTING

No amendments.

PSMJ 8 MEASUREMENT AND PAYMENT

PSMJ 8.2 SCHEDULED ITEMS

PSMJ 8.2.1 Provision of edge restraints

Add the following

"The rates shall cover all the costs for excavating, bedding, laying (including expansion joints), jointing, compacting and backfilling, including the removal of excess material."

PSMJ 8.2.2 Construction of paving complete

Delete the first sentence of this clause and replace with the following:

No separate items will be scheduled for straight, raking and circular cutting.”

Add the following

"The tendered rate shall also include full compensation for cutting units to fit edge restraints and for the removal of waste material from the Site."

TABLE OF CONTENTS

Page

PSMK 1 SCOPE

No amendments.

PSMK 2 INTERPRETATIONS

No amendments.

PSMK 3 MATERIALS

PSMK 3.1 CONCRETE

Add the following:

"The Contractor shall timeously submit the concrete mix design for cast-in-situ kerbing to the Engineer for approval and no kerbing shall be placed before the mix design has been approved."

PSMK 3.2 PRECAST KERBING AND CHANNELLING

PSMK 3.2.1 General

Add the following:

"The profile/dimensions of precast kerbs and channels must be in accordance with the details shown on the drawing."

PSMK 3.9 BEDDING MATERIAL

Replace the contents with the following:

"The kerbing and channelling will be placed on a bed of concrete with a minimum grade of 15 MPa/19 and 100 mm thickness."

PSMK 4 PLANT

No amendments.

PSMK 5 CONSTRUCTION

PSMK 5.1 EXCAVATION AND BEDDING

Replace "90%" *with* "93% (100% for sand)"

PSMK 5.2 KERBING AND CHANNELING OF PRECAST CONCRETE

Replace the first sentence with:

"Kerbing and Channelling of precast concrete must be placed on a concrete bedding as required in PSMK 3.9".

PSMK 5.11 TRANSITION SECTIONS AND INLET AND OUTLET STRUCTURES

Delete the words "and with the requirements of the Specification" *in the second paragraph*.

PSMK 6 TOLERANCES

No amendments.

PSMK 7 TESTING

PSMK 7.2 CAST-IN-SITU AND EXTRUDED KERBING AND CHANNELLING

PSMK 7.2.1 General tests

Delete this subclause.

PSMK 7.2.2 Alternative tests

Replace the heading and contents of this subclause with the following:

"Tests

The Contractor shall carry out a minimum of three cube crushing tests before the any kerbing is placed to prove the required compressive strength to the Engineer. Thereafter, a minimum of three cube crushing tests shall be done per 200 m of kerbing placed. The cost of such tests shall be deemed included in the rates tendered for kerbing.

One cube crushing test shall consist of a set of six cubes made with concrete taken from the mixer, the kerbing machine or from any part of the work as ordered.

If, after three cubes of any set of six cubes have been tested after 28 days in an approved laboratory, the average crushing strength is found to be more than 3 MPa below the specified strength, the kerbing represented by the cubes will be rejected.

The Contractor may apply for resubmission of the rejected section on the basis of cores drilled from this section and tested for the estimated actual crushing strength in accordance with SABS method 865 (excluding Appendix A). The cost of drilling and testing the cores is for the Contractor's account, regardless of the outcome of the tests on the cores. The number of cores required will be determined by the Engineer and the criterion for rejection or acceptance of the section represented by the cores shall be as specified above for cubes."

PSMK 7.3 RESPONSIBILITY FOR THE COST OF TESTING

Delete this subclause.

PSMK 8 MEASUREMENT AND PAYMENT

PSMK 8.2 SCHEDULED ITEMS

PSMK 8.2.1 Concrete kerbing

Replace "5.8.2" *in the third line of paragraph (e) with* "5.8.3".

PSMK 8.2.3 Variation of tests on extruded kerbing

Delete this subclause.

PART C3.5: STANDARD SPECIFICATIONS

C3.5: STANDARD SPECIFICATIONS

The standard specifications on which this contract is based are the latest edition of South African Bureau of Standards Standardized Specifications for Civil Engineering Construction SABS 1200 series. Although not bound in nor issued with this Document, the following Sections of the Standardized Specifications of SABS 1200 shall form part of this Contract:

("SABS" has been changed to "SANS, without change to the contents of the specifications.)

A	-	GENERAL
AB	-	ENGINEER'S OFFICE
C	-	SITE CLEARANCE
D	-	EARTHWORKS
DB	-	EARTHWORKS (Pipe Trenches)
DK	-	GABIONS AND PITC HING
DM	-	EARTHWORKS (Roads, Subgrade)
H	-	STRUCTURAL STEELWORK
HA	-	STRUCTURAL STEELWORK (Sundry Items)
HB	-	CLADDING AND SHEETING
L	-	MEDIUM-PRESSURE PIPELINES
LB	-	BEDDING (Pipes)
LC	-	CABLE DUCTS
LD	-	SEWERS
LE	-	STORMWATER DRAINAGE
LG	-	PIPE JACKING
ME	-	SUBBASE
MF	-	BASE
MJ	-	SEGMENTED PAVING
MK	-	KERBING AND CHANNELLING

The following SANS specifications are also applicable to this document and the Contractor is advised to obtain them from Standards South Africa (a division of SABS) in Pretoria.

SANS 1921 (2004)	:	Part 6: HIV/AIDS Awareness. (With regard to this specification, the payment clauses in the Bill of Quantities remain in accordance with the SABS 1200 series of specifications).
SANS 1914 (2002)	:	Parts 1 – 6.
SANS 10400-T (2011)	:	Fire Protection
SANS 10400-W (2011)	:	Fire Installation