MOKOLO AND CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

TENDER NO 054/2024/PMID/MCWAP2/RFB

PART C3.1
SPECIFICATION

SECTION 34

AC MITIGATION AND CATHODIC PROTECTION

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SECTION 34

AC MITIGATION AND CATHODIC PROTECTION

34.1 SCOPE

This Section deals with system component design, the manufacture, shop assembly and testing, supply, installation, Site testing, Site commissioning, all operating and maintenance during the Defects Notification Period of the temporary and permanent Cathodic Protection (CP) systems and alternating current (AC) mitigation system on the pipeline constructed under this Contract.

The work required for shall be done as per the system specifications and requirements set out below under the direction of a specialist AC Mitigation and Cathodic Protection Representative of the Engineer. Due to the nature of the investigations and system component designs required under this section, the final testing and design validation regarding the system design work will be monitored by the specialist AC Mitigation and Cathodic Protection Representative. This will be done progressively during the construction of the pipeline.

This Section 34 shall be interpreted as follows:

a) For the Employer design it shall be regarded as a specification; and

b) For the Contractors system component design it shall be regarded as an Employers requirement.

This document shall be read in conjunction with Section 28 – Mechanical General, Section 37 – Painting and Corrosion Protection, Section 38 – Electrical General, Section 39 – Electrical Plant and Installation and Section 48 – Tests on Completion.

34.2 DEFINITIONS, ABBREVIATIONS AND REFERENCES

34.2.1 Definitions

For the purpose of this document:

a) **“Manufacture”** includes, as applicable, the purchase of materials or goods, manufacture, fabrication and assembly, any specified corrosion protection measures and any off-site inspection or testing of materials or parts.

b) **“Installation”** includes, as applicable, all handling and transport from storage, if necessary, all erection and setting to work.

c) **"Performance Specification"** means the Employers requirement.

34.2.2 Abbreviations and Material Symbols

For the purpose of this Document, the following shall have the meaning given:

A	:	Ampere (unit for electrical current)
AASHTO	:	American Association of State Highway & Transportation Officials
AC	:	Alternating current
ACIM	:	AC interference mitigation
ASTM	:	American Society for Testing and Materials

BS EH	:	British European
CD	:	Capacitive discharge
CDT	:	Current Drainage Test
CP	:	Cathodic protection
CSE	:	copper / copper sulphate reference electrodes
CSV	:	Comma separated values
DC	:	Direct current
DCVG	:	Direct Current Voltage Gradient
DFT	:	Dry film thickness
DGPS	:	Differential global positioning system
GPR	:	Ground potential rise
HDG	:	Hot-dip galvanised
HVTL	:	High voltage transmission lines
Hz	:	Hertz (unit of frequency)
ICCP	:	Impressed Current Cathodic Protection
ISO	:	International Organisation for Standardization
MMO	:	Mixed metal oxide anode
MOV	:	Metal Oxide Varistor
NGL	:	Natural ground level
NACE	:	NACE International.
Ω	:	Ohm
PDF	:	Portable document format
PVC	:	Polyvinyl chloride
RE	:	(Portable) reference electrode
r.m.s.	:	root mean square
SACP	:	Sacrificial anode cathodic protection
SANS	:	South African National Standards
SRE		Stationary (permanent) reference electrode
SPD	:	Surge Protection Device
SS	:	Stainless steel
SS-DCD	:	Solid state DC decoupling device
USB	:	Universal Serial Bus
V	:	Volt
VLD	:	Voltage Limiting Device
XLPE	:	Cross-linked polyethylene

34.2.3 References

When reference is made to a Code of Practice, Specification or Standard, the reference shall be taken to mean the latest edition or replacement at time of tender of the Code, Specification or Standard; including addenda, supplements, modifications and revisions thereto. Where a previous version is intentionally used, it will be indicated as such. Where reference is made to a Code, Specification or Standard that has subsequently been withdrawn and not replaced, the intended content will remain relevant unless confirmed otherwise in writing by the Engineer.

34.3 DESIGN AND GENERAL REQUIREMENTS

34.3.1 Design

34.3.1.1 General

The materials used, the component design and the cathodic protection provided shall comply with the relevant system requirements set out below.

34.3.1.2 Drawings

The Contractor shall be responsible for submitting relevant component design, construction and installation Drawings to the Engineer for approval, within 12 weeks of the award of the Contract. The Drawings shall be submitted as per the requirements set out in Section 38 – General Electrical, Clause 38.19.2 and shall confirm the information provided in the tender and include dimensions and material details of plant offered for approval.

The Contractor shall also be responsible for “as-built" drawings of all CP Stations, AC mitigation stations and all hardware and Plant installed as part of this Contract.

34.3.2 Electrical Continuity

The pipeline must be electrically continuous within defined sections, generally demarcated by in-line valves. Where electrical continuity is required as detailed in the drawings and bill of quantities, all flanged components shall be made electrically continuous by means of a continuity bond. Continuity bonding around valve chambers where bolted flanges, dismantling flanges or couplings are found will be achieved either by external buried cables or internal cables mounted on the valve chamber walls, as designated in the bill of quantities.

34.3.2.1 Continuity Bonding Around the Outside of Chambers

Bonding cables will be attached to the pipe(s) each side of the valve chamber wall. Excavation around the chamber will be in accordance with the relevant specifications.

Two off double insulated single core 35 mm² copper cables laid in parallel shall be thermit welded separately directly to the pipe overt.

Continuity bonding shall include excavation, cable connections, making good of coating and lining systems to original coating system, test and back filling. All cables shall be clearly identified by means of permanently marked plastic ferrules with black lettering on a yellow background. Ferrules shall be the slip-on type and matched to the size of the cable.

34.3.2.2 Continuity Bonding Around the Inside of Valve Chambers

One off 16 mm² double insulated single core copper cable shall be welded to the pipe overt where the pipe protrudes through the chamber wall on the upstream and downstream sides. The cables coming from the upstream and downstream sides must be installed against the chamber walls using 15mm galvanised conduit and connected via a link panel for selective continuity. Continuity bonding shall include cable connections, making good of coating and lining systems to original coating system, conduit, saddles, terminations and link panel. All cables shall be clearly identified by means of permanently marked plastic ferrules with black lettering on a yellow background. Ferrules shall be the slip-on type and matched to the size of the cable.

34.3.2.3 Continuity Bonding of Buried Couplings

Buried flanges shall be made continuous by means of 2 off 25 x 5mm steel flat-bars welded across the flanges prior to encapsulation.

Buried VJ couplings shall be made continuous by 2 x 35mm^2, single core, double insulated, black cable (including 6 x welds and coating make good).

34.3.3 Cathodic Protection Test Stations

Cathodic Protection and AC Interference Mitigation monitoring test facilities (recording, bonding and current measurement) shall be located inside purposely provided bunkers located at air valve chambers, access tee chambers or other chambers as directed.

The enclosure shall be manufactured from 30 MPa concrete and shall be a minimum of 150 mm thick and shall be reinforced with hot-dip galvanised (HDG) mild steel (minimum 8 mm diameter).

The vandal resistant enclosure shall be manufactured from 5 mm (min) thick 3Cr12 plate which shall be reinforced as required. Corrosion protection of enclosures shall be multi-purpose epoxy plus re-coatable polyurethane (System 414) as specified in Section 37 – Painting and Corrosion Protection – Electrical Panels and Enclosures (Outdoor).

A common key vandal resistant (stainless) steel locking mechanism shall be utilised to lock the 3Cr12 enclosure. Details of the locking mechanism shall be submitted to the Engineer for approval before manufacturing or construction of the enclosure.

The internal enclosure shall be at least 800 mm x 420 mm x 450 mm (H x D x W) and accommodate the 75mm uPVC (Class 12) duct for a portable reference electrode.

The enclosure shall be installed with a concrete foundation, base and 2.0 m by 2.0 m x 250 mm thick concrete surround with reinforced 100 mm x 100 m x 6 mm HDG mild steel mesh. The reinforcing mesh shall be connected to a cable that is to terminate within the enclosure, should an equipotential plane be required or AC interference mitigation.

Inside the lockable enclosure, the 75 mm uPVC (Class 12) tube shall extend above a 2.5 mm thick stainless steel Grade 304L gland plate, to permit the portable reference electrode to be installed directly into the soil (via the uPVC duct) with no outside interference.

The contractor shall submit details and drawing for an appropriate terminal board / link panel of polycarbonate, or GRP, to be mounted in the bunker with associated ducts penetrating through the floor of the bunker for cables.

34.3.3.1 Bunker Test Point Facilities (Type A)

Type A bunker connection panels require connections for the following:

- 2 sacrificial anode cables;
- Pipe power cable;
- Pipe monitor cable; and
- VLD from gradient control mat.

Type F-A bunker connection panels require additional connections for the following:

- SSDCD from zinc ribbon.

34.3.3.2 Recorder-Type Test Point Facilities (Type B)

Type B bunker connection panels require connections for the following:

- 2 sacrificial anode cables;
- Pipe power cable;
- Pipe monitor cable;
- VLD from gradient control mat;
- AC Coupon with 10 ohm 50W resistor;
- DC Coupon with 10A slow blow fuse; and
- Stationary reference electrode.

Type F-B bunker connection panels require additional connections for the following:

- SSDCD from zinc ribbon.

34.3.3.3 Bonding Type Test Point Facilities (Type C)

Type C bunker connection panels require connections for the following:

- Pipe power cable;
- Pipe monitor cable;
- Foreign pipe power cable;
- Foreign pipe monitor cable;
- VLD from gradient control mat;
- AC Coupon with 10 ohm 50W resistor;
- DC Coupon with 10A slow blow fuse; and
- Stationary reference electrode.

Type F-C bunker connection panels require additional connections for the following:

- SSDCD from zinc ribbon.

34.3.4 Sacrificial Anode Cathodic Protection

Each SACP station shall consist of 2 shallow vertical wells varying between 12 m and 16 m depth (200 mm nominal diameter). The wells will be located 3 m from the pipe centreline, on one side of the valve chamber and 5 m apart, with the bunker installed adjacent to the valve chamber, unless otherwise shown on the Drawings or instructed by the Engineer.

The active length will be un-cased and the inactive length will have a PVC casing.

The active length of each well will vary between 7 m and 11 m, and consist of 6 m to 10 m 3.57 kg/m zinc ribbon consisting of 1 m lengths with flexible 10 mm^2 x 100 mm long interconnections with spacers to centralize in the steel casing.

50/50 gypsum / bentonite backfill is required for active length and washed river sand backfill for the inactive length.

34.3.5 AC Interference Mitigation (Increased Voltage Mitigation)

34.3.5.1 Gradient Control Wires

Gradient control wires or mitigation wires are typically installed parallel to the pipe as a grounding or earthing mechanism. These wires are also referred to as ribbons. The gradient control wires are generally installed for the following two main reasons: (i) to provide an earthing point which earths induced pipeline currents and reduces the overall pipeline voltage, and (ii) to reduce the coating stress voltages and touch voltages in their vicinity by changing the potential of the soil around the pipeline (ground potential rise or GPR).

In the case of one ribbon placed parallel to the pipe, it would generally be placed on the side closest to the overhead powerlines and at the invert level of the pipe. The second ribbon would be placed on the opposite side of the pipe. The ribbon should have a minimum separation distance to the pipeline of 200 mm. These ribbons are connected to the pipe by means of a cable through a DC decoupling device.

If the zinc wires are to be installed in discrete sections, it would generally be limited to 400 m in length with the connection to the pipe made in the middle of such a section. In such a case the ends of consecutive sections must be more than 1 m from one another.

Gradient control wires shall be zinc ribbon. The composition of the zinc shall be as per ASTM B418-95 – Type II, and suitable independent compositional testing (once per batch) shall be carried out by an accredited laboratory, in addition to the quality control information presented by the supplier of the zinc wire.

The zinc wire linear weight is linked to its geometry and shall at least adhere to the requirements as specified in Table 34/1.

TABLE 34/1
ZINC RIBBON SPECIFICATION

Aspect	0.983 kg/m Ribbon	1.785 kg/m Ribbon
Zinc weight	0.893 kg/m	1.785 kg/m
Cross section (D1 x D2)	12.7 mm x 14.3 mm	22.2 mm x 15.8 mm
Radii (R1 x R2)	2 mm x 5 mm	2 mm x 5 mm
Steel Core Wire diameter	≥ 3.3 mm	≥ 3.4 mm
Potential	-1.1 VCSE	-1.1 VCSE

If required, jointing of the zinc ribbon shall be made by exposing the steel core wire and jointing this with a hex crimped ferrule with silver solder. The exposed wire jointed part is then encapsulated with zinc (10 mm minimum cover) by casting this around the joint.

The gradient wire shall be covered with Bedding material used for backfilling the pipe.

34.3.5.2 Lumped or Nodal Grounding Mat

Lumped grounding or earthing is often required as an additional mitigation measure or as a measure on its own. The gradient control wires are installed for the following two main reasons: (i) to provide an earthing point which earths induced pipeline currents and reduces the overall pipeline voltage, and (ii) to reduce the coating stress voltages and touch voltages in their vicinity by changing the potential of the soil around the pipeline (ground potential rise or GPR).

Lumped grounding (earthing) shall be by means of a mat constructed from zinc ribbon. The mat is to be made up by affixing the zinc ribbon at right angles to form a square followed by further zinc ribbon inside this square to form blocks. The dimensions of the square and the spacing of the internal wires shall be in accordance with the specifications and the drawings. At each wire cross point the steel wire core is to be exposed and the steel wire is to be spot welded to one-another. The exposed wire jointed part is then then encapsulated with zinc (10 mm minimum cover) by casting this around the joint.

The grounding mat shall be zinc ribbon. The composition of the zinc shall be as per ASTM B418 - 95 – Type II, and suitable independent compositional testing shall be carried out by an accredited laboratory, in addition to the quality control information presented by the supplier of the zinc wire.

The zinc wire geometry shall at least adhere to the following:

Cross section (D1 x D2)	:	12.7 mm x 14.3 mm
Radii (R1 x R2)	:	2 mm x 5 mm
Zinc weight	:	0.89 kg/m
Steel Core Wire diameter	:	3.3 mm
Potential	:	-1.1 VCSE

Such a grounding mat would generally be placed on the side closest to the overhead powerlines and not more than 900 mm below finished ground level. The zinc mat would be connected to the pipe by means of two cables through DC decoupling device. Refer Clauses 34.3.5.3 and 34.3.6.

34.3.5.3 DC Decoupler for Zinc Ribbon and Lumped Zinc Grounding Mat

The grounding (earthing) system that is achieved by zinc material shall not be connected to the pipeline directly but only through a solid-state DC decoupling device (SS-DCD). Such a device shall be housed in a pre-cast concrete bunker. The device shall be certified by a suitably accredited test laboratory to meet the specifications given in Table 34/2.

TABLE 34/2
PERFORMANCE SPECIFICATION FOR DC DECOUPLING DEVICE FOR GRADIENT CONTROL WIRE (RIBBON) AND LUMPED GROUNDING MAT

Specification / Test	Level / Requirement	Comment
Class 1 impulse current rating	10 kA., 10/350 µsec	to SANS 61643-1 requirement
Front of wave spark-over voltage	≤ 500 V, 1.2/50 µsec	to SANS 61643-1 requirement
Rated AC short circuit	3.7 kA r.m.s., 1 sec, 50 Hz	to SANS 61643-1 requirement
Rated AC load current	45 A r.m.s., 50 Hz, max temp incr. 40º C	at maximum DC blocking voltage, to SANS 61643-1 requirement
AC impedance at 50 Hz	≤ 0.04 Ohm	at rated load current
DC blocking voltage	-3 V/+1 V (+/-10%)	Progressive characteristic.
DC. leakage (blocked)	≤ 1 mA	at AC load thermal limit
DC current withstand	10 A for 15 mins	without overheating, test in both directions

Specification / Test	Level / Requirement	Comment
Housing dielectric withstand voltage	5.8 kV	to SANS 61643-1 requirement
Environmental, enclosure	IP55	adjust upwards for more extreme environments
Ambient temperature range	-15º C to 60º C	
Air clearance and creepage distances	10 mm and 15 mm min respectively	to SANS 61643-1 requirement
Protection against direct contact	no direct contact	Using IEC60529 test finger
Basic insulation level required	2 500 VAC	

Additional requirements for the DC decoupling device are:

The decoupling device shall comprise a suitably rated diode stack capable of blocking direct current in both directions at the specified voltages.

The device shall exhibit a progressive, smooth transition from blocking to conduction to and vice versa without commutating.

A bypass capacitor (network) shall be connected in parallel with the diode stack to conduct 50Hz AC up to the blocking voltage of the diode stack.

The capacitor (network) shall be protected by a suitably rated surge protection device (SPD) for high voltage and lightning-induced transients. The SPD shall be decoupled from the capacitor and diode network with the appropriate inductance, in accordance with SANS 61312-3. This inductance shall remain effective (i.e. not saturated) during simultaneous transient and maximum DC current conditions.

The decoupling device shall preferably be of open frame construction to permit maintenance and replacement of component parts. The frame shall be sized to fit on a standard 800 mm x 600 mm chassis plate.

The decoupling device shall be provided with two M10 terminals at each installation point for the connection of 35 mm² single core cables.

The housing for the components shall be supplied with a danger warning sign for High Voltage at an obvious place on the unit.

The SS-DCD shall be supplied with wiring diagrams and general arrangement Drawings. All relevant and necessary dimensions together with block wire diagrams shall be supplied prior to manufacture, supply and installation for approval by the Engineer. Details of the enclosure and layout shall also be provided

34.3.5.4 Equipotential Apron (Mats) / Plane

Gradient control wires or mitigation Equipotential aprons or mats are required at all locations of the exposed pipeline appurtenances (i.e. valve chambers, bunkers and test posts, structures in contact with the pipe, structures housing components that are connected to the pipe) on the pipeline sections where specified.

Equipotential aprons shall be implemented with steel weld mesh mats or rebar grids.

Steel weld mesh installation at chambers or bunkers (or structures) shall be as follows:

The concrete apron is usually placed on the finished ground level around the structure (or buried at a depth as shown on the drawings). The apron shall only be placed on firm undisturbed ground or a compacted prepared base. The dimension of the concrete apron shall be at least 1.2 m from any part of the structure.

A 200 mm x 200 mm reinforcing steel weld mesh of 6 mm diameter steel wire (not galvanized) mesh ref number 193 extending 1.2 m beyond the external wall of the chamber. All overlaps shall be 200 mm minimum joined by welding at least every 400 mm to form an electrically continuous system.

For circular chambers the weld mesh shall be two overlapping panels with a circular cut-out to achieve a 1.2 m distance from side of the chamber – the mesh may be cut square if preferred on condition that the minimum distance of 1.2 m is achieved.

The weld mesh is centrally located in an 85 mm thick Class 15/19 MPa concrete slab.

The mesh panels are connected to the pipeline with two cables through a decoupling device and the cables be kept as short as possible (≤ 1.5 m). Refer to Clause 34.3.6.

Continuity in a reinforced steel concrete structure relies on the interconnection of the re-bar (reinforcing). The reinforcing is then equipped with at least two (2) connector plates (5 mm thick steel with a 12 mm hole for cable connection) which is welded to the mesh / re-bar protruding through the wall at suitable positions. The connector plates are connected to the pipeline with a cable through a voltage limiting device and the cables kept as short as possible (≤ 1.2 m).

For air valves using pre-cast concrete rings as walls, the steel reinforcing is generally inaccessible and only the reinforcing in the concrete floor is connected to the pipeline.

34.3.5.5 Decoupler for Equipotential Plane

The equipotential planes for pipelines equipped with a Cathodic Protection system shall not be connected to the pipeline directly, but only through a suitable decoupling device. Such a device shall be housed in a valve chamber or a dedicated enclosed AC mitigation station as appropriate. The device shall be certified by a suitably accredited test laboratory to meet the specifications given in Table 34/3.

TABLE 34/3
PERFORMANCE SPECIFICATION FOR DECOUPLING DEVICE FOR EQUIPOTENTIAL MATS OR STEEL REINFORCING OF A CONCRETE STRUCTURE

Specification / Test	Level / Requirement	Comment
Nominal impulse discharge current rating	10 kA., 8/20 µsec wave form	to SANS 61643-1 requirement
Voltage protection level	≤ 400 V	to SANS 61643-1 requirement
Response time	≤ 25 nsec	
Short circuit withstand	3.7 kA r.m.s., 1 sec, 50 Hz	to SANS 61643-1 requirement

Specification / Test	Level / Requirement	Comment
Housing dielectric withstand voltage	5.8 kV	to SANS 61643-1 requirement
Maximum continuous AC operating voltage	75 Vr.m.s. (+/-10%)	
Maximum continuous DC operating voltage	100 V (+/-10%)	
Operating state / Fault indication	Green / Red	Mechanical switch
Environmental enclosure	IP55	Adjust upwards for more extreme environments
Ambient Temperature	-15º C to 60º C	
Air clearance and creepage distances	10 mm, 40 mm respectively	to SANS 61643-1 requirement
Protection against direct contact	IP4X	Using IEC 60529 test finger

The housing for the components shall be supplied with a danger warning sign for High Voltage at an obvious place on the unit.

34.3.6 Cabling

All connections of cathodic protection and AC interference mitigation materials and plant to the pipeline and equipotential apron / mat / structure reinforcing, are to be made with single core multi-strand copper cables. All cables are to be insulated as specified and rated for voltages up to 600 V / 1 000 V. The stranding shall be in accordance with SANS 1507.

TABLE 34/4
CABLE SPECIFICATION (UNLESS SPECIFIED OTHERWISE ON THE DRAWINGS)

Purpose	Size (mm^2)	Insulation	Colour
Pipe to VLD in chamber / bunker	25	PVC/PVC	Black
Pipe to DC decoupler in chamber / bunker	35	PVC/PVC	Black
Pipe to a link coupling for monitoring in chamber / bunker	16	PVC/PVC	Black
Pipe to chamber / bunker in ground for monitoring or coupons	16	XLPE/PVC	Black
Pipe to chamber / bunker in ground for VLD	25	XLPE/PVC	Black
Pipe to chamber / bunker in ground for DC decoupler	35	XLPE/PVC	Black
AC Coupon to link coupling in chamber / bunker	Two Core 6	PVC	Blue
Grounding wire (ribbon)	35	PVC/PVC	Yellow / Green

Purpose	Size (mm^2)	Insulation	Colour
Grounding to mat / apron / chamber mesh	25	PVC/PVC	Yellow / Green
Continuity bonding in chamber	16	PVC/PVC	Black
Cross bonding and continuity bonding in soil around a structure	2x 25	PVC/PVC	Black
Continuity bonding in soil around a flange	2x 5 mm thick steel flat welded to flange	Encapsulate with bituminous product	N/A

The cable to zinc connections shall comprise of suitably sized hex crimped ferrules between the cable and the steel core of the zinc ribbon. The ferrule shall be silver soldered after crimping. The whole joint and an overlapping section past the jointed area shall be encapsulated with an approved self-vulcanizing butyl rubber tape and heat shrink mastic lined tube with a 2.5 mm after recovery thickness.

Splicing of cables underground shall be avoided. However, should splicing be required, a suitable compression fitting and press tool shall be used or alternatively a line tap if an additional cable is to join the main cable. The connections are to be waterproof epoxy filled splicing kits. The cable insulation is to be roughened with 160 grit sand paper before the epoxy is poured into the mould. The epoxy is to completely cover the exposed cable and jointing material and shall fill the mould completely. Sufficient time must be allowed for the epoxy to set (as per manufacturer's instructions) before the joint is buried. The epoxy splicing kit may not be used if the expiry date has passed.

Lug connections shall be made with heavy duty copper with electroplated tin connector lugs of appropriate size. A heat shrink sleeve shall be provided to seal off the break in insulation and the lug and this sleeve is to protrude sufficiently past this point to make a waterproof seal.

Cable markings shall be one of the following types:

- Snap-on plastic marker of suitable size with engraved black lettering on yellow background.
- Stainless steel strip tape with information punched in (minimum letter height 4.5 mm) with metal fixing ties.

34.3.7 Cable Connections to Pipe

34.3.7.1 General

A suitable method to secure cables to pipes is required to allow for continuity bonding, cross bonding, pipe to test post connections, CP, ACIM component connections to be made.

The connection of a cable to the steel pipe is preferably made at any thicker part available at the jointing locality – such a thicker part be a pad specifically provided for this purpose, the socket of an insert type connection, a flange, or any other suitable thicker material part.

Cable connection on thin walled pipes (less than 8 mm thick) or pipes lined with epoxy or polyurethane requiring any form of heat must be made with the pipes full of water unless the pipe has been supplied with thermit welding pads. Any such welding must be preceded with by a trial on a spare pipe and the lining subjected to a holiday detection test (spark test) before and after the attachment.

A detailed application and quality control procedure for any proposed cable connection to pipe is required after successful trials have been made and a proposed cable connection method is established.

Thermit welding is the preferred method should it comply with the requirements. Stud welding or thermit welding with solder pads are the alternative preferred method of cable attachment on thin wall pipes (i.e. wall thickness less than 8 mm).

34.3.7.2 Thermit Welding

As far as possible, cables are to be connected to the pipe barrel at a field joint prior to field joint repair and coating make good or at a flange.

The area where thermit welding is to take place shall be thoroughly cleaned to provide an area approximately 75 mm x 75 mm. All traces of petroleum mastic, concrete, pipeline coating, primer material or any other matter must be removed and the surface is to be brushed with a steel wire brush. Prior to making the weld the area must be roughened using a coarse file or flapper disc, and preheated with a portable gas torch.

The end of the insulated cable must be made bare for at least 25 mm. A retaining cap in the bottom of the mould is placed and the weld powder is poured into the mould. The weld is covered with the starting powder. The cable is then placed on the pipe and the mould squarely over the cable, pressing it down firmly. The lid is closed, the starting powder is ignited with a flint gun which allows the weld to solidify. The mould is removed and the residue is cleaned out in preparation for the next weld.

After the above procedure has been carried out, the weld shall be tested by tapping the weld with a 2 kg hammer. Should any movement occur the cable shall be re-welded and re-tested.

34.3.7.3 Stud Welding

Remove section of pipe coating using a portable sanding device. Remove all traces of dirt and degrease.

The weld gun must be manually loaded with an appropriately designed stud and pressed onto the pipe surface in such a way that the supporting feet touch the surface of the pipe. The welding process is initiated by actuating the start button. Against the force of the pressure spring, the gun coil lifts the lifting mechanism with the welding stud off the surface of the pipe by the set gap distance. The power thyristor of the welding unit is triggered. The gun coil is switched off-circuit so that the stud is accelerated back onto the pipe surface by means of the pre-tensed pressure spring. As soon as the ignition tip of the stud touches the surface of the pipe, the welding circuit is closed. The high capacitor discharge current of the welding unit has the effect that the ignition tip of the stud partially evaporates. In so doing, the ignition gap between the surface of the pipe and the stud is ionised and welding arc is ignited.

As a result of the heat charge of the welding arc, the fore-part of the stud and an area of the pipe surface of approximately the same size melt so that a pool of molten mass forms on the areas to be welded. When the stud makes contact with the surface of the pipe, the arc goes out. Before the molten mass hardens the stud is pressed by the force of the spring. The remaining energy of the capacitor battery is discharged in a short circuit. The weld gun can then be removed from the welding stud immediately afterwards.

Connect the lugged cable to pipe using stud welder.

34.3.7.4 Pin Brazing

The technique used shall ensure that metallurgical contact is achieved between the cable and the pipe. Details of the equipment to be used must be submitted to the Engineer before being applied.

The minimum area of coating shall be removed. After connecting the cable the entire exposed area shall be encapsulated in epoxy. The procedure for this is as follows:

- Clean the remaining coating to at least 50mm beyond the final repair limits;
- Construct a dam from a suitable material around the coating repair area; and
- Apply 2 component (squish pack) over the repair area, ensuring a minimum 1 mm cover over the cable connection (Epoxy 151 UW or similar product approved by the Engineer). A minimum overlap of 50 mm shall be made over the existing coating.

34.3.7.5 Making Good of the Coating System

All coating repairs at cable connections shall be made in accordance with the repair procedures relevant to the coating system applied to the pipe. Refer to the relevant clauses in Section 37.

If cables are attached to the barrel of the pipe, these attachments should be made at field joints to minimise the number of repairs required. If the pipe is epoxy lined, then repairs will also be required to the internal lining.

Any attachments to the barrel of the pipe which are buried, will require repair using circumferential wrapping. Patch repairs may not be used in buried applications.

Cable connections to epoxy or [polyurethane] coated fittings in valve chambers shall be encapsulated with epoxy as specified in Clause 34.3.7.4 or a heat applied bituminous patch.

34.4 MATERIALS AND PLANT MANUFACTURING

34.4.1 General

All materials shall possess qualities adequate for the purpose for which they are to be used. All materials and properties claimed for these materials shall, unless specified otherwise in this document, comply with the requirements of the latest edition of the appropriate South African or other internationally recognised standard specification at the time of Tender.

For each type of Plant, the manufacturer and or supplier shall indicate the materials used for each of the proposed sub-assemblies.

The Plant shall be manufactured using new prime quality materials taking into account the latest technical innovations. Recycled and/or reconstituted materials will only be considered if they are fully justified and approved by the Engineer prior to manufacture and/or supply.

The Engineer retains the right to request and obtain full references of suppliers and materials and Plant supplied as well as all original copies of all the material’s Certificates of Conformity regarding raw materials used to manufacture products.

34.4.2 Compatibility of Materials

The responsibility for selecting materials, which are compatible with the liquids or surroundings with which the Plant comes into contact, to prevent corrosion and/or abrasion rests with the Contractor. The materials used shall be at least equal to those specified in this Specification.

34.4.3 Electrical Cables

All cables supplied and installed shall conform to the requirements of Annexure 34/1 and Section 39 – Electrical, Clause 39.1.4 – Cables and Cabling of the Specification.

Cable designations, sizes and insulation requirements are listed in Clause 34.3.6.

34.4.4 Stationary Reference Electrodes (SRE)

All stationary reference electrodes (SRE's) shall be designed for permanent burial. All SRE's shall be of the Zinc / Zinc Sulphate (Zn) type and calibrated to a calomel reference electrode with a tolerance <10 mV. Certification and approval shall be furnished prior to delivery of any SRE.

34.4.5 Zink Sacrificial Anodes

Zinc ribbon anodes shall be ASTM B418 Type II or Grade ZN1. The ribbon shall be extruded with a 4.2 mm central steel core and be at least 34 mm x 26 mm with 5 mm radius on bends (equivalent 25 mm diameter). The capacity shall be 780 Ampere hours per kilogram with a potential of -1100 mV_{CSE}. The mass shall be minimum 3,57 kg per linear meter for SACP installations. The Zinc shall be flexible and not brittle.

Anodes shall be pre-assembled in 1 m sections to the required length as "sausage strings" with anode tails and interconnections of 10 mm² flexible double insulated cable.

Zinc anodes may be extruded or cast with a central steel core and a net mass of > 3.6 kg with a minimum length of 1 metre.

34.4.6 Sacrificial Anode Backfill

Backfill for zinc anodes used for permanent SACP shall be 50% gypsum / 50% calcium bentonite. The backfill column shall be minimum 200 mm diameter.

Backfill shall be supplied to site pre-mixed in granular, free-flowing consistency to facilitate filling of vertical anode boreholes.

34.4.7 Insulating Flange Kit

An insulating flange consists of an insulating gasket, bolt sleeves and washers, appropriately sized steel bolts and nuts and washers and a voltage limiting spark gap for protection of the insulating materials.

The insulating gasket between flanges to be in accordance with Table 34/5 based on pipe diameter and pressure rating. The I.D. of the pipe and gasket shall in all instances be equal.

TABLE 34/5
INSULATING GASKETS

No	Field Test Pressure (MPa)	Nominal Pipe Diameter (mm)	Insulating Gasket Material
1.	Lower or equal to 4.6	All diameters	3 mm aramid fibre / nitrile rubber (Novus 34 or equivalent approved by the Engineer) full face gasket in one piece.

Insulating sleeves shall be a minimum 1 mm thick glass fibre reinforced epoxy resin sleeve for each bolt. Total length of sleeves is to be 2-3 mm less than the length between inside faces of steel washers. The insulating sleeves shall fit completely inside the insulating washers.

Insulating washers shall be 6 mm thick LHM G11 silicon glass with O.D. the same as that of machined steel washer, 2 off for each stud bolt. The I.D. to be a sliding fit over the insulating sleeve.

Steel washers shall be machined with diameter and thickness as indicated in Table 34/6.

TABLE 34/6
MACHINED WASHERS

Stud bolt Diameter (d)	Machined Washer Thickness
d </= 36mm	6mm
36mm < d </= 42mm	8mm
d > 42mm	10mm

Stud bolts and studs shall be grade 8.8 and nuts grade 8 to SANS 1700. Stud bolt diameters shall be selected to the next smaller size for installation in standard drilled flanges. Stud bodies shall be machined down to the next standard smaller size and suitable smaller nut to be used.

Special stepped stud bolts shall be used for blind tapped holes opposite spindles in valve bodies.

Explosion-proof Spark Gap Type ExFS™ L300 shall be installed across the flange faces complete with hot-dip galvanised mild steel mounting brackets to suit the flange bolt, as supplied by Dehn or similar approved by the Engineer. The width of the holding bracket of the explosion-proof spark gap shall be the same as the steel and insulation washers and the bottom end be rounded off to fit into the spot faced area of the valve and/or steel flange.

The outer rims of the flanges must be wrapped circumferentially with a white plastic backed polymer modified bituminous tape, or similar approved, 1,5 to 2,0 mm thick with a minimum 25 mm overlap. In case of surface irregularities, i.e. raised face flanges, etc., an approved mastic material shall be used to provide a smooth contour for subsequent tape application. A 25 mm wide plastic backed electrical tape (SANS 122-1975) coloured red shall be applied in the centre on the horizontal surface. A metal tag shall be attached via a 1 mm stainless steel locking wire through a 2 mm hole drilled in the tag and in the most overt insulating flange bolt. The following is to be stamped on the metal tag:

"OPERATING INSULATING FLANGE"

34.5 INSTALLATION AND OPERATING REQUIREMENTS

34.5.1 Electrical Continuity

The steel pipeline will be electrically continuous in defined sections between in-line valves. Where required, in-line valves will be bonded either internally within chambers through a link panel or externally with buried cables, as detailed in the installation schedule. All buried flanged joints will be bonded prior to encapsulation.

34.5.2 Insulating Flanges (IF)

In order to effect isolation from the earth conductors of electrical actuators, IF kits will be installed each side of each actuated in-line valve and in accordance with the CP and AC mitigation design.

Insulation at pump stations is installed on the first suitable flange inside the pump station precinct as designated on the drawings.

Insulating flanges are required both sides of electromagnetic flow meters.

After installation, all insulating joints must be inspected and tested to ensure their compliance with the Specifications and Drawings. The proposed test method and sequence shall be agreed with the Engineer in order to ensure the efficiency and compliance regarding electrical isolation. The inspection shall be witnessed by the Engineer and tested by the Contractor.

34.5.3 Valve Chamber Test Stations

All cables shall be terminated using tinned copper bootlace ferrules or blade / pin lugs. All cables shall be labelled.

All cables will be interconnected through appropriate link panels as shown on the Drawings.

Pipe cables shall be connected inside each valve chamber and brought into the test station bunker.

Type B test points shall be installed at nominal 500m intervals at air valve and access chambers associated with SACP installations, as directed in the installation schedule.

Stationary reference electrodes and coupons shall be installed at pipe mid-line at Type B locations on the opposite side of the valve chamber to the sacrificial anodes as designated in the installation schedule.

Type C test points are required at all foreign pipeline crossings, and/or parallel sections and/or convergence and/or divergence from the foreign pipelines as indicated on the Drawings or by the Engineer.

Type F test stations will incorporate the requisite SSDCD’s.

34.5.4 AC Interference Mitigation Systems

Installation of AC Interference Mitigation systems shall take place concurrently with pipe laying.

Temporary connections from the zinc ribbon to the pipe may be made prior to installation of bunkers at valve chambers if necessitated by high AC potentials.

Permanent connection of the zinc ribbon will be made through the SSDCD in the bunker adjacent to the chamber.

34.5.5 Permanent SACP Installation

Shallow boreholes are located 3 m from the pipe centreline and 5 m apart, unless otherwise indicated on the Drawings or instructed by the Engineer.

Shallow boreholes for permanent sacrificial anode installation shall be drilled 200 mm ø to full depth as indicated in the installation schedule. A steel casing may be utilised to facilitate drilling and stabilise the hole, but must be removed.

The inactive cover section shall be sleeved with PVC to the depth indicated in the installation schedule.

The requisite number of anodes to match the active depth of the borehole shall be lowered into the borehole using centralisers and a bio-degradable (sisal, cotton or hemp) rope.

The active section and of the borehole and 1m of the inactive cover section shall be filled with granular gypsum / bentonite. The inactive section of the borehole shall be filled with washed river sand. This may require topping up to compensate for settlement / compaction.

The feed and return cables from the borehole shall be routed to the adjacent bunker and terminated directly on the link panel.

34.5.6 Records

The following complete records shall be kept on site for inspection by the Engineer and handed over at the end of the Contract. The location of each excavation, anode excavation and/or anode, test point, AC mitigation enclosure, cross bond to any foreign service pipeline and/or any cable or bond shall be marked and numbered with the allocated tag number before any photo is taken.

34.5.6.1 Permanent anode ground-beds (SACP)

a) Individual anode DGPS position and depth of installed anode and photographed.

b) Anode header cable route (all bends) DGPS position and cable depth (no joints).

34.5.6.2 Test Points and DC Cable Connections to the Pipeline

a) Pipeline depth and DGPS position;

b) Photograph of exposed pipeline (before coating removal - if applicable);

c) Photograph of pipeline with coating removed and/or pipeline cleaned;

d) Photograph of welded cable connections (before priming and re-coating);

e) Photograph of re-coated area (as per Section 37);

f) Description and photograph of bedding / padding material;

g) Description and photograph of test point foundation;

h) Photograph of test point installation and surround;

i) Photograph of test point terminations and connections;

j) Coupons;

k) SRE;

l) Bunker installation including Concrete Test Results;

m) Details of keys and locks; and

n) Drawings, data sheets, etc.

34.5.6.3 AC Mitigation Test Points and AC Mitigation Cable Connections

a) DGPS position of zinc ribbon at start point, end point including all bends and description and photograph of zinc ribbon bedding / padding material;

b) Nodal installation details;

c) DGPS position and photograph of all zinc ribbon joints;

d) Record and description of all equi-potential earth grids / mats including records of the installation, progressive compaction and reinstatement;

e) Description and photograph of AC mitigation enclosure foundation;

f) Description and photograph of AC mitigation enclosure installation and surround;

g) Photographs of AC mitigation terminations and connections; and

h) Drawings, data sheets, etc.

34.5.6.4 Bonding to Other Pipelines

a) Pipeline depth and DGPS position at crossing and/or bond location;

b) Pipeline exposed (before coating removal) and photographed;

c) Pipeline coating removed;

d) Welded cable connections (before priming and re-coating) and photographed;

e) Re-coated area (full circumferential wrap with 50% overlap) and photographed;

f) Bedding / padding material and photographed;

g) Test point foundation;

h) Test point installation and surround; and

i) Test point terminations and connections.

34.6 TESTING / COMMISSIONING

34.6.1 General

All CP and AC interference mitigation plant and material shall be energised and/or tested at the manufacture or Contractors facility prior to site release.

34.6.2 Factory Acceptance Testing

Factory Acceptance Testing (FAT) shall take place at the manufacturer's facility in accordance with section 48.4.

34.6.3 Testing of Insulating Joints (IF Kits)

Insulating joints are to be housed in a well-drained and ventilated chamber / area with inspection access.

Insulating joints shall not leak at field test pressure.

After installation, the insulating joints must be inspected to ensure their compliance with the specifications and drawings and tested for satisfactory electrical insulation. The inspection shall be witnessed by the Engineer.

A radio high frequency tester should be used to test the insulation of the joint. The test shall be performed on each side of the flange as well as on each bolt-nut set individually.

Re-testing must be carried out upon replacing any faulty component.

34.6.4 Testing of Solid-state DC Decouplers

The solid-state DC decoupler (SS-DCD) shall be tested at the Contractor's expense at the Works or at an independent third-party inspectorate's laboratory / works in the presence of the Engineer. A sample of the SS-DCD to be supplied shall be made available for testing purposes. All of the SS-DCD device components shall pass the tests prescribed below and as per the equipment / component type test data sheets. One complete item shall be fully tested to destruction. The Contractor will issue a Test Certificate upon completion of the tests which shall be signed by the Engineer.

The SS-DCD device shall be tested at 125% of the fault current rating and for at least 10 cycles of a standard 50 Hz cycle. The pre-set DC blocking voltage shall be tested and confirmed. At least 125% of the steady state AC shall be passed through the unit for a minimum 15 minute period. No item and/or component of the SS-DCD shall fail. Failure of a single item / component shall imply complete failure of the SS-DCD device.

The Engineer may also call for other pertinent tests in order to prove compliance.

34.6.5 Current Drainage Testing (CDT)

The pipeline itself must be electrically continuous and all other civil structures and extraneous earths shall be electrically isolated from the pipeline at pump stations, off-takes, chambers, scour valves, air valves, isolating valves, non-return valves, etc. by means of insulating flange kits, etc. The pipeline shall not be bonded to Foreign Service pipelines unless designed accordingly and subsequent to interference testing.

All sacrificial anodes and AC mitigation systems shall be disconnected for the purpose of the CDT during construction. Current drainage testing shall be conducted in accordance with NACE TM0102. It is recommended that not more than 5,000 m of pipeline be tested at any given time. See Section 37.34.4.

On completion of construction, the CDT shall be repeated. This may be undertaken utilising the sacrificial anode cathodic protection system or an external power supply. In the event that an external power supply is used, all sacrificial anodes must be disconnected. See Section 37.34.5.

The acceptance criterion for all CDT is a specific conductance <60 µS/m^2.

34.6.6 Energising, Commissioning and Hand-Over

The Contractor shall provide a suitably qualified technician and/or technicians to jointly energise and commission the CP system.

This shall include for:

- Energising and commissioning all SS-DCD;
- Commissioning - Corrosion Coupons;
- Commissioning - IR free potentials;
- Commission – interference testing (AC/DC);
- Commissioning - Data logging (CP TP and AC mitigation sites);
- Electrical Completion Certificate; and
- Mechanical Completion Certificate.

The Contractor shall provide the required equipment, vehicles and personnel to effectively carry out the required services.

34.6.7 CP and AC Interference Monitoring

As permanent protection for MCWAP-2 is provided by a sacrificial anode cathodic protection system, this system shall be installed in parallel with the laying and backfilling of pipes to ensure protection of the pipes against corrosion also during construction and no temporary CP installation will therefore be required.

The pipeline potentials (DC and AC) shall be monitored by the Contractor from the time the first pipe section is backfilled until the permanent CP system is commissioned and is handed over. Baseline potential DC and AC readings are required from the pipe sections prior to connecting any CP and ACIM components to the pipe.

Pipe monitoring shall comprise bi-weekly pipe recordings at all monitoring points. DC potentials shall be measured using spot measurements. AC potential and coupon current shall be recorded over a period of 40hours. DC & AC monitoring shall alternate at fortnightly intervals. This information is to be correlated to determine the effective operation of the CP and ACIM systems. The Contractor shall submit bi-weekly reports of the monitoring and recordings to the Engineer for evaluation.

34.7 STANDARDS

The following Standards and Codes of Practice with all relevant amendments and attachments shall be utilised as part of the Works where details and/or information is not specifically covered within this Specification. Any conflicts and/or contradictions shall be brought to the attention of the Engineer in writing who shall review the conflicts and/or contradictions and submit written clarification in this regard.

In addition, Standards and Codes of Practice listed in the performance specifications included in the Annexures will also apply.

Standards Australia

AS/NZS 4853	Electrical Hazards on Metallic Pipelines.

International Organisation for Standardization

ISO 14555	Welding - Arc stud welding of metallic materials.

International Standards and Procedures

ASTM B – 8	Concentric-Lay Stranded Copper. Conductors
ASTM B418	Cast and Wrought Galvanic Zinc Anodes Used For Cathodic Protection
DIN 50925	Corrosion of metals; proof of effectiveness of cathodic corrosion protection of underground installations
NACE TM0102	Measurement of protective coating electrical conductance for underground pipeline
NACE TM0109	Techniques for aboveground evaluation of the coating condition of underground metallic pipelines
NACE SP0207	Performing close-interval DC pipe-to-electrolyte potential surveys on buried or submerged metallic pipelines
NACE SP0502	Pipeline external corrosion direct assessment methodology
NACE SP0286	Standard Practice: Electrical isolation of cathodically protected pipelines
NACE SP0177	Standard Practice: Mitigation measures of alternating current and lightning effects on metallic structures and corrosion control systems

South African National Bureau of Standards

SANS 121 (ISO 1461)	Hot dip galvanised coatings on fabricated iron and steel articles.
SANS 122	Pressure-sensitive adhesive tapes for electrical purposes (Metric units)
SANS 1411	Materials of insulated electric cables & flexible cords
SANS 1411 Parts 1 to 7	Materials of insulated electric cables and flexible cords
SANS 1507 Parts 1 to 6	Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1,900/3,300 V).
SANS 1700 SET	Fasteners
SANS 10064	Preparation of steel surfaces for coating.
SANS 10140	Parts 1 to 3: Identification - Colour Marking.
SANS 10142 Part 1	The wiring of premises Part 1: Low-voltage installations
SANS 10129	Plastic tape wrapping of steel pipelines.
SANS 13509	Cathodic protection measurement techniques
SANS 15589 -1	Cathodic protection of pipeline transportation systems: Part 1: On-land Systems
SANS 50162	Stray Currents
SANS 53509 (EN 13509)	Cathodic protection measurement techniques

SANS 50162 (EN 50162) Protection against corrosion by stray current from direct current systems

SANS 60479-1 (IEC TS 60479-1) Effects of current on human beings and livestock

Other Standards and Guidelines

Eskom 240-66418968 Guideline on the electrical co-ordination of pipelines and powerlines

34.8 GUIDELINES FOR SAFE WORKING PROCEDURES

The following guidelines for safe working procedures at pipeline construction close to high voltage overhead powerlines are applicable:

Attention!

This is not a comprehensive safety procedure. This Procedure provides some of the general safe practices and is not a comprehensive manual. The intention of this procedure is to raise the awareness of potential dangers to the pipeline construction team caused by nearby electrical circuits and to define some minimum safety requirements. The Contractor remains fully responsible for safe working procedure in terms of the Contract.

34.8.1 Introduction

When construction activities occur within electrical power line servitudes, there are a number of issues that need to be considered that are influenced by the relative localities of the pipeline and overhead power line or power cable.

Unsuspected voltage can be present on a pipeline (and pipes ready for constructing a pipeline) through Conductive, Inductive as well as Capacitive coupling between a pipe or pipeline and the nearby electrical circuits.

During a power line fault or lightning strike, very high voltages can be induced in the pipeline, which can damage the cathodic protection systems, rupture the coating, and present a significant safety hazard for any person close to or in contact with the pipeline and its appurtenances. During normal operation the induced pipeline voltages are lower, but could still present a safety hazard and can result in accelerated corrosion of the pipeline.

Any raised electrical potentials found on a pipeline should be reported to a competent person so that the cause is understood and that appropriate mitigation measures can be implemented. This section should not be viewed as a restriction to use better methods and it should be understood that a generalized account does not make provision for unpredictable or un-expected circumstances.

(a) Additional Abbreviations for this Section

ESA Electrical Supply Authority

HVDC High Voltage Direct Current

LVAC Low Voltage Alternating Current : <1 kV

MVAC Medium Voltage Alternating Current : 1 kV to 33 kV carried on Distribution Lines (Dx)

HVAC High Voltage Alternating Current : 44 kV to 132 kV carried on Distribution Lines (Dx)

EHVAC Extra High Voltage Alternating Current : >132 kV carried on Transmission Lines (Tx)

Note: Direct connection (including arcing danger) is relevant for all overhead powerlines regardless of the system normal voltage it is known for (it therefore includes low voltage system as well).

34.8.2 Normative / Informative Documents

The latest edition at time of project commencement of all the normative documents shall be regarded as forming part of this document and shall have equal standing. In case of a conflict this document shall take precedence.

The Contractor is to obtain its own copy of these publication(s) and shall have a copy available at the construction site.

34.8.2.1 Normative Documents

(a) NACE standard SP0177 titled "Mitigation of Alternating Current and Lightning Effect on Metallic Structures and Corrosion Structures"

Attention is drawn to section 5.3: "Construction".

The minimum protective measures for AC influence are provided in the NACE SP0177 standard, and this should be followed on the site of Works.

This document is available from the National Association of Corrosion Engineers (NACE) International and can be purchased online from their web site (*www.nace.org)*.

(b) Eskom guideline titled "Guideline on the Electrical Co-ordination of Pipeline and Power Lines" with unique reference number 240-66418968

A copy of this document can be downloaded from the Corrosion Institute of Southern Africa website (www.corrosioninstitute.org.za under the TAB Core Knowledge – Publications).

The normative and informative documents listed in this Eskom guideline form part of the suite of documentation that shall be applied to the construction activities where applicable.

34.8.3 Electrical Safety Officer

An Electrical Safety Officer (ESO) shall be appointed for the site of Works prior to any work commencing close to or within an electrical powerline servitude.

The ESO shall have sufficient training to understand basic electricity as well as specialist training on steel pipe construction close to electrical powerlines.

The ESO shall have the following minimum qualifications as per Eskom Guideline on the Electrical Co-ordination of Pipeline and Power Lines:

- Completed the Eskom's Operating Regulations for High Voltage Systems (ORHVS) responsible person training course;

- Be authorised by an ORHVS authorised person (GMR2.1) to work without constant supervision in a power line servitude;
- Completed the South African Electrolytic Corrosion Committee (SAECC) Electrical Safety Officer training course; and
- Experience in the supervision and management of temporary mitigation measures during pipeline construction.

The ESO must be furnished with the authority and equipment required to implement and maintain safe working conditions. The ESO shall have the required measurement instruments and equipment to measure AC and DC potentials with respect to adjacent ground and remote earth.

The ESO shall keep a record of any non-compliance and advise the construction manager (site agent) and the project safety officer.

34.8.4 General Safety Requirements

a) All construction personnel and visiting persons entering the site of Works shall be made aware of and able to recognize the potential shock hazards and be trained in appropriate safety measures. The awareness shall be for electrostatic (capacitive), electromagnetic (inductive) and conductive coupling (resistive) conditions.

b) All overhead electrical power lines should be regarded as being “live” (i.e. connected to a power supply causing a carrying potential (voltage) which is dangerous.

c) The Contractor shall determine and have available on site the local representative name and contact details of the electrical supply utility(s). The Contactor shall have local liaison with the electrical utility to know when planned switching, outages, load changes or any changes that may affect the pipeline induced or capacitive voltages. Work involving contact with the pipe and pipe sections shall be stopped during scheduled switching and re-closing of the electrical power system.

d) Qualified personnel shall measure and record the pipeline voltage to earth to verify that conditions are safe to work (i.e. Vac < 15 V rms.), on all sections and on each day prior to the commencement of any construction or other activity involving contact with the pipeline.

e) For pipeline voltage measurements, a voltmeter of suitable range and impedance shall be used. Low resistance earth connections shall be used to avoid induction or capacitive pickup on test leads and related items that could result in erroneous readings on a high impedance instrument.

f) Test leads shall be attached to the instrument first and then to the pipeline. After measurement, the leads shall be removed from the pipeline first and from the instrument last.

   Each time a voltage measurement is made, the following minimum data shall be recorded:

   i) Location;
   ii) Time;
   iii) Date; and
   iv) Pipe-to-earth voltage.

g) An adequate record keeping systems shall be developed and kept up to date by the Contractor. This record keeping shall include all daily recorded measurements and readings in an orderly manner.

34.8.5 Arrangements Regarding Work Within and Near to a Powerline Servitude

Note: This section is relevant when working near to or within all overhead powerlines and underground cables with a system normal voltage >1 kV (i.e. all MVAC, HVAC, and EHVAC as well as any DC overhead powerlines).

a) No work may commence within a powerline servitude unless the Electrical Supply Authority (ESA) (Eskom or other institution) has issued a letter of consent and the Contractor has submitted a letter of acceptance to the conditions of the ESA. The application, letter of consent and acceptance letter from the Contractor must be available on site at the site offices at all times.

b) If permission has been granted, the Contractor must give at least 7 working days prior notice of the commencement of work.

c) The Electrical Supply Authority (ESA) (Eskom or other institution) shall at all times have unobstructed access to and egress from its servitude areas.

d) The construction of temporary (or permanent) metallic fences can be extremely hazardous and is prohibited without written approval from the relevant ESA.

e) The use of explosives of any type within 500 m of a powerline or cable servitude is not permitted without the written consent from the relevant ESA.

f) Changes in ground level may not infringe the statutory ground to conductor clearances or the statutory visibility clearances.

g) The Contractor is to report any damage to the ESA property, private property or public facilities to the relevant authority. Repair measures are to be agreed upon and a signed off completion inspection release is required from the relevant authority for each case.

h) No excavations are permitted within the following distances of any above ground powerline structure (includes tower structure, guy wires, anchors and any other attachment):

- MVAC & HVAC : 6 m
- EHVAC : 20 m

i) No above ground buildings or temporary structures are allowed within the servitude areas and the following additional distances from the centre line of a MVAC & HVAC (i.e. up to 132 kV) powerline applies:

- All voltages < 22 kV and 22 kV : 9 m
- From >22 kV to 88 kV : 11 m
- From >88 kV to 132 kV : 18 m

j) No above ground buildings or temporary structures are allowed within the servitude areas and the following additional distances from the centre line of an EHVAC (i.e. >132kV) powerline applies:

- From 220 kV to 275 kV (delta) : 18 m
- From 220 kV to 275 kV (horizontal) : 23.5 m
- From 132 kV to 400 kV (self-supporting) : 23.5 m
- From 132 kV to 400 kV (stayed) : 27.5 m
- From >400 kV to 765 kV : 40 m

k) The ESO must be in contact with the electrical utility to know of planned switching, outages, and load changes that may affect pipeline voltage. Work involving contact with the pipeline shall be stopped during scheduled switching of the electric power system.

l) When the AC mitigation measures agreed upon by the Eskom and the Employer have been installed, an Eskom representative must be requested to inspect all the components of this installation and to perform necessary measurements according to the inspections required.

m) Final approval of the CP and AC mitigation installation is subject to the outcome of this inspection by Eskom.

34.8.6 General Safe Working Procedures Within and Near to a Powerline Structure

a) No person, equipment or machinery shall enter the HVAC, EHVAC or HVDC servitude without the approval of the ESO. All affected areas shall be suitably demarcated and access restricted to those personnel who have been advised of the hazards and requirements when working underneath or adjacent to HVAC, EHVAC or HVDC power lines.

b) All personnel shall be made aware of and be able to recognize the potential shock hazards and be trained in the approved safety procedures.

c) Pipeline construction personnel shall avoid contact with HVAC, EHVAC or HVDC structures and supports. No mechanical equipment shall come closer than 5 m from any power line tower.

d) Direct connections to the power line tower structures or buried counterpoise earthing system are not permitted under any circumstances. The earthing systems of the power line and the pipeline must be kept separate.

e) Temporary construction sheds, trailers, living quarters, pipe sections, storage areas or vehicle fuelling facilities are not permitted in the HVAC, EHVAC or HVDC servitude.

f) Vehicles such as mobile cranes with extendable members that can potentially exceed the minimum vertical clearance height shall be identified and the operators issued with specific instructions with regard to the maximum permissible extension, prior to doing any work in the HV/EHV servitude.

g) If for any unforeseen reason, the life-threatening situation occurs where a construction vehicle comes into contact with a live HV/EHV conductor or a flash-over occurs, the operator(s) shall remain inside the vehicle and attempt to get it out of the contact situation using ONLY the vehicle’s own power. On NO account shall the operator(s) leave the vehicle and on NO account shall any person approach the vehicle, until the contact situation has been reversed, or until the ESO has received confirmation from the electricity utility that the power line has been de-energized.

   Arcing may temporarily stop due to the action of the protection, however this in itself shall NOT be taken as an indication that the line is safe, since the line may automatically attempt to re-energize. Effective assistance in this situation entails ensuring that all persons present maintain a safe distance from the vehicle (>10 m) and alarming the electricity utility’s operational centre.

h) Any foreign metal structures exposed during trenching inside or alongside HVAC, EHVAC or HVDC servitudes shall be treated as a live electrical conductor, until measurement proves otherwise.

i) The pipeline shall not be bonded to any foreign structures without an assessment by a qualified engineer and written permission from the owner.

j) The use, storage, disposal, treatment or generation of any hazardous substances shall not be permitted in the power line servitude.

34.8.7 Direct Connection (Conductive Coupling)

Note: This section is relevant for all overhead powerlines regardless of the system normal voltage it is known for (it therefore includes low voltage system as well).

a) When a power system with a grounded neutral has unbalanced conditions (e.g. during a power transmission tower fault) current may flow to the earth. Substantial currents in earth may result from phase-to-phase-to-ground or phase-to-ground faults. The following conditions may result from such faults:

- A metallic structure (e.g. a steel pipe) in the earth may form part of the current path; and
- A metallic structure (e.g. a steel pipe) in the earth that is coated with a dielectric material (i.e. insulated from the ground) may develop a significant AC potential across such coating.

Such an unbalance situation on medium and high voltage systems (i.e. >1 kV) usually seen as a short and the power supplier's equipment should automatically cut the power supply to that faulted system. Faults on low voltage power systems (i.e. 1 kV and lower) might go undetected for extended periods of time [*SANS10280-1Sec 11.1*]. Although the raised soil potential is concentrated within the immediate vicinity of the short, the hazardous electrical potential can be transported over long lengths in the metallic structure (e.g. pipe).

Touching the metallic structure during the duration of the short can cause fatal electrical shock.

b) All persons on site of Works shall avoid contact with MVAC, HVAC, EHVAC or HVDC powerline structures and its supports. No mechanical equipment shall come closer than 5m from any powerline structure and associated element.

c) Upon entering or crossing a LVAC, MVAC, HVAC, EHVAC or HVDC powerline servitude, appropriate warning signage shall be erected. Such warning sign shall have the electrical hazard sign with the wording warning against overhead powerlines, viz:

d) A minimum or four (4) signs are to be erected – two facing the approaching direction (one on each side of the pipe route) and the other two the opposite direction (one on each side of the pipe route). The signage shall have reflective markings yellow with black lettering and symbol on steel plate. The overall signage size shall at least be 600 mm wide. The signage shall be erected at a suitable height on treated wooden poles (100 mm minimum diameter) planted in the ground. The signage shall be maintained in good condition throughout the Contract period and removed upon completion of the project.

e) The minimum vertical clearance between construction equipment and bare overhead conductors shall be in accordance with SANS 10280. The actual height of the conductors at their lowest point shall be measured by means of optical measuring equipment and during a hot day to ensure that this minimum clearance is achieved.

The following are minimum clearances for the nominal rms Voltages:

- Up to 44 kV : 3.0 m
- Over 44 kV up to 66 kV : 3.2 m
- Over 66 kV up to 88 kV : 3.4 m
- Over 88 kV up to 132 kV : 3.8 m
- Over 132 kV up to 220 kV : 4.5 m
- Over 220 kV up to 275 kV : 4.9 m
- Over 275 kV up to 400 kV : 5.6 m
- Up to 533 kV DC : 6.1 m
- Over 400 kV up to 765 kV : 8.5 m
- Over 765 kV : to be obtained by Contractor from the power utility.

The above clearances are from Regulation 15 of the Electrical Machinery Regulations 1998 of the OHS Act.

Vertical clearance is the open air distance between the top most part of a construction equipment or vehicle and the electrical wire conductor.

f) All work on a pipeline is to be stopped when lightning (electrical storm activity) is imminent or present at the site of Works. Any heavy weather with threatening lightning is sufficient cause to stop the works. Any heavy weather with threatening lightning or actual lightning along any remote part of an electrically continuous pipe shall result in immediate stopping of all works on the pipeline. In his case an electrically continuous pipe includes both sides of the pipe that is joined by means of an isolated joint as such a joint is not necessarily sufficient to block the voltages generated from lightning strikes.

34.8.8 Capacitive Coupling

a) Capacitive coupling is typically a hazard during construction with respect to electrical shock or arcing when the structure (e.g. a pipe section) is on isolated supports (e.g. wooden chocks) prior to being installed into the ground. Although generally not dangerous, it may cause involuntary movements when electrical discharge happens through a person which can cause secondary harm or damages. Monitoring of voltages on pipes stored in this manner within 1 km of an overhead electrical servitude is advised. Appropriate grounding of these sections are recommended.

b) On pipelines paralleling AC powerlines and for pipe routes crossing powerlines, temporary electrical grounds shall be installed and maintained up to backfilling at 300 m intervals, commencing from 1 km from the powerline coming close to the pipeline or when the AC potentials rise as the pipe approaches the vicinity of the powerline. Sufficient temporary grounds are to remain until adequate permanent grounding connections are made. Temporary ground can be done with adequately sized cables (35 mm² insulated stranded copper wire) and a simple driven ground rod. Grounding to any existing semi-conductor may not be done unless authorized by the ESO.

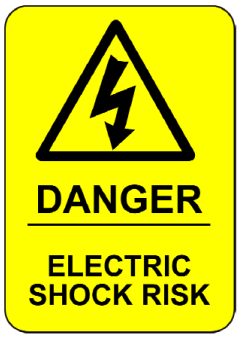
c) In all servitude areas of HVAC and EHVAC and HVDC power lines, machinery and vehicles with rubber tyres should be equipped with a heavy duty steel chain fixed to the chassis with a length to allow 1 m of chain to freely drag along the ground to discharge any electrostatic build-up.

34.8.9 Inductive Coupling

a) Inductive coupling from overhead high voltage powerlines can result in dangerous AC voltages and current flow in the adjacent metallic structure (e.g. the pipe). Induced voltages may increase during power fault conditions. Pipeline voltage measurements are required on installed pipelines from 2 km of the overhead powerline or if the project specifications require it. These measurements are to be taken with a voltmeter of suitable range and impedance. A low resistance ground shall be established by means of a metal rod driven into the ground. Low resistance connections shall be used to avoid induction or capacitance pickup on test leads and related items that would result in erroneous readings on a high impedance instrument. Voltages more than 15 Vac are considered dangerous and work on pipelines must be stopped if this condition occurs. If AC voltages more than 5 V are measured, mitigation measures should be planned for implementation should an AC voltage of 15 V be reached.

b) A suitable recording instrument should be installed to measure AC voltages over a period of 7 days to determine peaks, anomalies and cyclic events if any meaningful presence of AC induced voltages are measured. The frequency of a repeat of the 7 day measurement should be determined in consultation with the powerline representative.

c) At every section of pipeline that experiences a voltage >15 Vac, electrical shock warning signage shall be erected. Such warning sign would have the electrical hazard sign with the wording “Danger – Electric Shock Risk”, viz:



d) Two signs per every 500 m of pipeline are to be erected adjacent to the pipeline – the signs are to be affixed back-to-back on one pole facing opposite directions. The signage shall have reflective markings yellow with black lettering and symbol on steel plate. The overall signage size shall at least be 600 mm wide. The signage shall be erected at a suitable height on treated wooden poles (100 mm minimum diameter) planted in the ground. The signage shall be maintained in good condition throughout the Contract period and removed upon completion of the project.

e) Pipelines exhibiting voltages greater than 15 Vac rms shall be earthed by means of temporary earth rods of at least 1,8 m in length and connected to the pipeline by means a green insulated stranded copper conductor with a cross sectional area of at least 35 mm^2. Prior to connecting the earth rod to the pipeline, the earth resistance of the earth rod shall be measured and if the earthing resistance is higher than 10 Ω additional rods shall be installed in a crow’s-foot configuration with a spacing of 2 m.

Pipelines parallel to AC power systems shall be earthed opposite the midpoint of each span, maximising the distance to the nearest HVAC or EHVAC structure.

The temporary connections to the pipeline shall be made with earthing clamps that apply firm pressure at the contact point with a mechanically sound connection, and with the coating at the contact point removed down to the bare metal.

Temporary ground rods shall be installed at intervals of 300m or less (the evaluation and optimum solution is to be determined for each site),

Temporary earths shall be left in place until immediately prior to backfilling. Sufficient temporary earths shall be maintained on each section until adequate permanent grounding connections have been made.

f) When the pipeline voltage remains above 15 Vac rms in spite of the temporary earth rods, temporary earth mats that extend a minimum of 1 m outside the work area shall be used. The connection between the pipeline earthing clamp and the temporary earth mat shall be made with 25 mm² or larger stranded copper cable. There shall be no contact between persons over the earth mat and those not over the mat, including the handing over of tools or materials.

g) To prevent the risk of personal injury or arc burns, the connection and disconnection of temporary earths shall be carried out in the following order:

For connection:
- The earthing clamp is connected to the pipeline.
- The earthing cable is connected to the earth rod.
- The earthing cable is connected to the earthing clamp.

For disconnection:
- The earthing cable is disconnected from the earthing clamp.
- The earthing cable is disconnected from the earth rod.
- The earthing clamp is removed from the pipeline.

h) The above measures shall be provided when any activity takes place where contact with the pipe is required, e.g. for welding pipes together, cutting of pipe, surface preparations and coating operations, coating applications at field joints, coating repairs, bolting fittings onto flanged ends of the pipe, etc.

i) When cutting pipe, adequate bonding across the location of the cut shall be ensured irrespective of the AC voltage measured between the pipeline and earth The AC potential on the pipe shall be measured and additional earthing installed if this voltage exceeds 15 V AC rms before the cutting commences.

j) For lowering pipe into the trench that is to be connected to the installed pipeline, the coated pipe section shall be handled with non-conductive slings. All contact with the bare part of the pipe shall be avoided until the pipe is connected with the grounded pipe.

k) Bonding cables should be provided to bridge any gap between two pipe sections (e.g. where a valve is to be installed).

l) Work over insulating joints, flanges or couplings may only proceed after the AC voltage status has been measured. A temporary bond across the flange or the use of a properly sized temporary earth mat shall be used to protect personnel while they work on the pipe.

m) Where coating is to be applied at field joints or for any other reason (such as repairs), precautions shall be taken to ensure that equipment contacting the bare pipe is adequately bonded and earthed.

34.9 OPERATING AND MAINTENANCE MANUALS

The following data and documentation as minimum shall be submitted in a Data Pack or as part of the Operating and Maintenance Manuals required in terms of Clause 48.9:

a) Data Pack (electronically and 3x paper copies):

- As-built drawings;
- Workshop drawings;
- FAT and SAT documentation;
- Coordinates of all AC Mitigation & CP components to sub-meter accuracy. DGPS raw data files of TRU, TP, ACM, groundbed and cable routes;
- Signed off installation sheets;
- Method statements;
- Specification and data sheets, certificates and details of all temporary and permanent CP materials used;
- All information required in terms of the Specification including all photographs, DGPS raw data files, etc.; and
- Operation and Maintenance Manuals for all electrical and mechanical components.

b) Operating and Maintenance Manual to contain as a minimum:

- Operating and maintenance instructions for electrical and mechanical components; and
- Operating and maintenance instructions for remote monitoring.

34.10 MEASUREMENT AND PAYMENT

The rates tendered under this section shall not include for the general obligations and work deemed to be covered by the items provided in Part C3.1, Section 1 – General.

The CP and AC Interference Mitigation systems shall be deemed to be fully inclusive of all sundry items, such as cable joints, ferrules, lugs, heat shrink, labels, etc., All equipment required to install these sundry items shall also deem to be included in the installation costs such as hydraulic crimping tools, heat guns, grinders, etc. The tendered rates or sums shall cover the cost of anything not specially mentioned, but which an experienced Contractor can reasonably foresee as being required to enable the apparatus and equipment to be installed and/or function safely and correctly as specified. No claims whatsoever for extras will be allowed on the grounds that a necessary piece of plant or part thereof is not specifically mentioned in the Bill of Quantities.

Tender rates or sums shall include for secure packaging to ensure that plant items are not damaged prior to installation and cover costs of delivery, storage, etc.

34.001 Construction DCVG Survey — Unit: Kilometre (km)

A DCVG coating integrity survey will be undertaken by the Contractor.

34.002 Coating Conductance Test (CDT) during construction — Unit: Number (No.)

Coating conductance tests will be undertaken by the Contractor at 5 km intervals.

34.003 Short DSR Survey **Unit: Provisional sum (PS)**

The short DSR survey will consist of a 200 m array at 5 m spacings. These will be conducted at the commencement of the Works at all CP groundbed locations by the Nominated Subcontractor (CP specialist).

A provisional sum is included, and a provision is made against this item for a percentage allowance on the net cost of the item.

34.004 SRB testing **Unit: Provisional sum (PS)**

The SRB testing will be conducted at 5km intervals along the pipeline route at the commencement of the Works by the Nominated Subcontractor (CP specialist).

A provisional sum is included and a provision is made against this item for a percentage allowance on the net cost of the item.

34.005 DC & AC Potential Monitoring **Unit: Provisional sum (PS)**

All CP & AC Monitoring will be undertaken by the Nominated Subcontractor (CP specialist). Monitoring commences from the time the first pipe section is buried and continues until the CP system is commissioned or at the request of the Engineer.

A provisional sum is included and a provision is made against this item for a percentage allowance on the net cost of the item.

34.006a Supply of continuity bonding cable inside valve chambers with inline valves and fittings **Unit: metre (m)**

The rate tendered shall include for full compensation of all costs incurred in the manufacture, procurement, supply and delivery to site of all materials and equipment required for installation of cable inside valve chambers with inline valves and fittings.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.006b Installation of continuity bonding cable inside valve chambers with inline valves and fittings **Unit: metre (m)**

The rate tendered shall include for full compensation of all costs incurred for the complete installation of cable inside valve chambers with inline valves and fittings.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.007a Supply of CP & ACM equipment **Unit: Number (No.)**

The rate tendered shall include for full compensation of all costs incurred in the manufacture, procurement, supply and delivery to site of all materials and equipment required for installation of the plant as detailed in the BOQ.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.007b Installation of CP & ACM equipment **Unit: Number (No.)**

The rate tendered shall include for full compensation of all costs incurred in the complete installation of the plant as detailed in the BOQ.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.008a Supply of Vertical groundbed **Unit: metre (m)**

The rate tendered shall include for full compensation of all costs incurred in the manufacture, procurement, supply and delivery to site of all materials and equipment required for installation of the vertical groundbed as detailed in the installation schedule.

The rate shall further include the supply of the following:

- Active length – 3.57 kg/m zinc ribbon consisting of 1 m lengths with flexible 10 mm^2 interconnections complete with spacers to centralize in casing (including 10 mm^2 anode tails from both ends), gypsum / bentonite backfill and terminations into link panel.
- Inactive length – PVC casing, sand backfill and excavation of cable trench from vertical hole to bunker (3 m).

34.008b Installation of Vertical ground bed **Unit: metre (m)**

The rate tendered shall include for full compensation of all costs incurred in the complete installation of the vertical groundbed as detailed in the installation schedule.

The rate shall further include the installation of the following:

- Active length – 3.57 kg/m zinc ribbon consisting of 1 m lengths with flexible 10 mm^2 interconnections complete with spacers to centralize in casing (including 10 mm^2 anode tails from both ends), gypsum / bentonite backfill and terminations into link panel.
- Inactive length – PVC casing, sand backfill and excavation of cable trench from vertical hole to bunker (3 m).

34.009a Supply of Zinc ribbon parallel to pipe **Unit: Kilometre (km)**

The rate tendered shall include for full compensation of all costs incurred in the manufacture, procurement, supply and delivery to site of all materials and equipment required for installation of single zinc ribbon.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.009b Installation of Zinc ribbon parallel to pipe **Unit: Kilometre (km)**

The rate tendered shall include for full compensation of all costs incurred in the installation of the single zinc ribbon prior to backfilling by the main contractor.

Payment will only be effected after full compliance of the items with the Specification has been certified by the Engineer.

34.010 Coating Conductance Test (CDT) **Unit: Provisional sum (PS)**

Coating conductance tests will be conducted on completion of construction and before the issue of the Taking Over Certificate (TOC) by the Nominated Subcontractor (CP specialist).

A provisional sum is included, and a provision is made against this item for a percentage allowance on the net cost of the item.

34.011 CIPS / DCVG Survey **Unit: Provisional sum (PS)**

A CIPS / DCVG survey will be conducted on completion of construction and before the issue of the Taking Over Certificate (TOC) and again at the end of the Defects Notification Period (DNP) and before the issue of the Performance Certificate by the Nominated Subcontractor (CP specialist).

A provisional sum is included, and a provision is made against this item for a percentage allowance on the net cost of the item.

ANNEXURE 34/1
PERFORMANCE SPECIFICATION / DATA SHEET:
CATHODIC PROTECTION CABLES

Performance Specification / Data Sheet : Cathodic Protection Cables					
Referenced Standards:					
ASTM D3222		Standard Specification for Unmodified Poly(Vinylidene Fluoride) (PVDF) Molding Extrusion and Coating Materials			
SANS 1507-1 to 6		Electric cables with extruded solid dielectric insulation for fixed installations (300/500 V to 1 900/3 300 V) Part 1 to Part 6			
SANS 1411-1 to 7		Materials of insulated electric cables and flexible cords Part 1 to Part 7			
ISO 9001:2000		Quality Control and Assurance Specification			
Design and Operating Details :					
Design Life:		*Min*	25 years and/or as required by the Design Specification		
Ambient Temperature:		*Min*	-6°C	*Max*	+48°C
Burial Temperature		*Min*	06C	*Max*	+15°C
Installed Conditions:		*Buried soil / electrolyte environment appropriate for service conditions*			
		Anode Cable Insulation to be suitable for installed conditions - low pH, Acidic, Oxygen or Halogen Gas evolution			
		Cables to be fully UV Stabilised for RSA Conditions			
Quality Control and Accreditation		*ISO 9001:2000 Certified Accreditation / SANS 1507 / SANS 1411 Certified and Accredited Supplier*			
Dimensions and Description:					
	1	*Length (Min)*	Minimum - As Specified (Maximum 5% Tolerance on supplied length)		
	2	*Length (Max)*	Maximum - As Specified (Maximum 5% Tolerance on supplied length)		
	3	*Cross Section ($mm^{2)}$*	As Specified with SANS 1507/SANS1411 Maximum Allowable Tolerance on supplied cable.		
	4	*Voltage Drop (V)*	Maximum Value as determine over length and specified cross sectional area as agreed by client and in accordance with SANS10142		
	5	*Operating*	Maximum Value as determine over length and specified cross		

		Temperature	sectional area as agreed by client and in accordance with SANS 1411/1507

Anode Cabling Details			
Insulation Layer	**Colo**	**Insulation**	**Rating**
Inner:	*As Specified*	*XLPE*	SANS 1507/1411 and suitably rated for service conditions - Original Manufacturers Certificate of Conformity
Middle / Outer (Double Insulated Cables):	*As Specified*	*PVC*	SANS 1507/1411 and suitably rated for service conditions - Original Manufacturers Certificate of Conformity
Inner – ICCP Anode	*As Specified*	*PVDF*	ASTM D3222 and suitably rated for service conditions - Original Manufacturers Certificate of Conformity
Steel Wire Armoured Cables (SWA):	*As Specified*	*Outer PVC*	SANS 1507/1411 and suitably rated for service conditions - Original Manufacturers Certificate of Conformity
Labelling:	*Ferrule Type (Black on yellow) suitably rated for service conditions - (Nominally every 10m for buried cables)*		
	Numbering / labelling in accordance with relevant block or relevant wiring diagram		

Inspection, Testing and Documentation			
Test Item	**Rating**		**Minimum Compliance**
Cable Insulation Test (660V/1000V)	*Max*	*1KV*	Original Test Certificate from cable manufacturer and testing as per relevant SANS1507 requirement
Cable Resistance Test (660V/1000V)	*SANS*	*As applicable*	Original Test Certificate from cable manufacturer and testing as per relevant SANS1507 requirement
Cable Conductor (Material and Capacity)	*SANS*	*As applicable*	Original Test Certificate from cable manufacturer and testing as per relevant SANS1507 requirement
Documentation			**Details and Requirements**
ISO 9001:2000 Certification:			Certified Copy of Valid Certificate

Cable Suppliers Original Test Reports:	SANS 1411 / ASTM D3222 Original Test Certificate from cable manufacturer. Certified Copy of Valid Certificate
	SANS 1507/SANS 1411 Manufacturing Accreditation Certificate. Certified Copy of Valid Certificate
	Material COC, Waybills, Delivery Notes, Delivery Documentation, etc.,