RAND WATER CATHODIC PROTECTION SYSTEM TECHNICAL SPECIFICATION – Revision 7.5 Rev 3

RW ELS 00001 TS

Contents

INTRODUCTION

This specification shall be used as a reference to the Bill of quantities and it defines the minimum requirements governing the design, installation and commissioning of a cathodic protection system.

REFERENCE DOCUMENTS AND STANDARDS

Latest editions of standards, codes and specifications shall be used by contractors and consultants should this specification make any reference to such Standards and codes.

APPLICABLE STANDARDS

Document Title	Document No.
NACE international standard practice – Control of external corrosion on underground or submerged metallic piping systems	SP0169 – 2007
The wiring of premises part 1: Low voltage installations	SANS 10142-1
The design and installation of an earth electrode specifications	SANS 10199
Materials of insulated electric cables and flexible cords part 1:conductors	SANS 1411-1
Materials of insulated electric cables and flexible cords part 2:poly-vinyl-chloride(PVC)	SANS 1411-2
Materials of insulated electric cables and flexible cords part 3:Elastomers	SANS 1411-3
Materials of insulated electric cables and flexible cords part 5 :cross – linked polyethylene(XLPE)	SANS 1411-4
Electric cables with extruded solid for fixed installations (300/500v to 1900/3300v) part 1:general	SANS 1507-1
Electric cables with extruded solid dielectric insulation for fixed installations (300/3300v) part 2:wiring cables	SANS 1507-2
Cathodic protection measurement techniques	SANS 53509:2009
Protection against corrosion by stray current from direct current systems	SANS 50162:2010
Petroleum and Natural gas industries – Cathodic Protection of pipeline transportation systems	SANS 15589-1:2009

SPECIFIC DEFINITIONS

Bill of quantities: (BOQ) – Pricing instructions that is in the tender document that contains the quantities to be supplied or installed.

Cathodic protection: - The process to reduce or prevent corrosion of metal structures in contact with an electrolyte by the flow of direct current from the electrolyte into the structure surface.

Impressed Current Cathodic Protection: (ICCP) – Cathodic protection system utilising anodes which are energized by an external DC power source. The ICCP system is designed to deliver relatively large currents from a limited number of anodes.

Sacrificial Anode Cathodic Protection: (SACP) - Cathodic protection system utilising sacrificial anodes which have a higher energy level or potential with respect to the structure to be protected. The SACP system is designed to deliver relatively small currents from a large number of anodes.

Cathodic protection station: - a combination of equipment installed to provide cathodic protection to the pipeline.

Drain point: - the point on the pipeline where the connection of the negative terminal of the cathodic protection voltage source is made to conduct (drain) the returning current from the pipeline to the voltage source.

Electrolyte: - a conductive liquid or material such as soil or water in which an electric current can flow.

Earth spike - 16 mm treaded type 1,5 m long electroplated SANS 1063

foreign structures/pipelines - metal structures, or pipelines other than the pipeline under consideration, in contact with the same electrolyte as the pipeline, and which are or may become under the influence of the pipeline's cathodic protection system. Foreign structures/pipelines may be owned by the Principal or other companies and may or may not be equipped with cathodic protection.

Groundbed - the system of buried or submerged electrodes, to conduct the required current into and through the electrolyte to the steel surface to be protected.

Lightning arrestor - Outdoor type

midpoint - the point on a pipeline between two cathodic protection stations where the influence of the two cathodic protection stations is expected to be equal and the protection levels are usually lowest.

Natural potential - the pipe to soil potential measured when no cathodic protection is applied and polarisation caused by cathodic protection is absent.

"OFF" potential - the pipe to soil potential measured immediately after the cathodic protection system is switched off and the applied electrical current stops flowing to the pipeline surface, but before polarisation of the pipeline has decreased.

"ON" potential - the pipe to soil potential measured while the cathodic protection system is continuously operating.

Pipe-to-soil potential: - the difference in electrochemical potential between a pipeline or foreign structure/pipeline and a specified reference electrode in contact with the electrolyte. Similar terms such as structure to soil potential, pipe to electrolyte potential are sometimes used as applicable in the particular context.

Polarisation: - the change of the pipe to soil potential caused by the flow of DC current between an electrolyte and a steel surface.

Polarisation cell (Kirkcell) - a device inserted in the earth connection of a structure that isolates for DC in the cathodic protection voltage range.

Reference electrode: – an electrode which the electro chemical potential is accurately reproducible and serves as a reference for pipe to soil potential measurements.

Sealer - Mastic putty, rubber tape and PVC insulation tape

Stray currents - electrical currents running through the electrolyte, originating from a foreign DC source which cause interaction with the corrosion and cathodic protection system and act upon foreign structures/pipelines.

LIST OF ACRONYMS

AC – Alternating Current

CH – Valve Chamber

CIPS – Close Interval Potential Survey

CP – Cathodic Protection

CSE – Copper Sulphate Electrode

DC – Direct Current

DCVG – Direct Current Voltage Gradient Survey

DSR – Deep Soil Resistivity

ECDA – External Corrosion Direct Assessment

FDU – Forced Drainage Unit

HV – High Voltage

IF – Insulating Flange

IJ – Insulation Joint

ISO – International organization OF standard.

ICCP – Impressed Current Cathodic Protection

NACE – National Association of Corrosion Engineers

NDU – Natural Drainage Unit

PCM – Pipeline Current Mapping

PSP – Pipe to Soil Potential

RW – Rand Water

SRB- Sulphate Reducing Bacteria

TRU – Transformer Rectifier Unit

TS001 TRANSFORMER RECTIFIER UNIT, FORCE DRAINAGE UNIT SUPPLY

The TRU/FDU shall be air-cooled (by natural convection) and consist of a single phase/ three-phase step down transformer and an automatically controlled rectification circuit. The TRU shall be capable of three types of control:

- Constant Voltage
- Constant Current
- Automatic Potential

The control of the output being either manual or automatic potential, in the manual mode, the output voltage shall be adjustable by a ten-turn potentiometer. The potentiometer controls the gate firing of the thyristors in the TRU, and so allows the output voltage to be set at a desired level.

Once the output voltage is set to a chosen value, this will not depart from that value, unless the rated current is exceeded. It may be used as a constant voltage control or as a voltage limit control.

There shall be a ten-turn potentiometer for setting the current to a chosen value. This may be used as a current limit control or as a constant current control.

The TRU controller automatically senses the reference input, which causes the thyristor controlled output to increase or decrease to reach a set level referred to as a “demand” level. The controller shall be able to accept up to six reference inputs and control selected from any one of the reference electrodes or the one indicating the least level of protection.

The “demand” or set level shall be adjustable by means of a ten-turn potentiometer and displayed on a meter. The meter may be switched to read the reference potentials REF 1, REF 2, REF 3, etc. up to REF 6 or set point.

The potential control module shall ignore open circuit or unused reference inputs, but if selected for control will turn the output of the TRU to zero.

The mode of control shall be user selectable.

Automatic potential control mode shall achieve and maintain control to within +/- 100mV of the set point under all conditions and output ranges

The output shall be controllable, in all three modes, across the full range without having adjustable voltage tapings see below to obtain low DC output control on the transformer. The output shall be smoothed such that the “ripple” is less than 2% across the full output range.

The TRU shall be provided with multiple tapings on the secondary of the Transformer and the Supplier to specify suitable tapings (e.g. 3, 6, 12, 18, 24, 48).

In addition to the multiple AC secondary tapings and DC output circuit ballast resistor shall also be provided. The ballast resistor shall be in the positive output of the TRU Rating to be confirmed by Rand Water.

The TRU shall have a remote monitoring system capable of transmitting the mode setting, the set point potential, the measured actual potential, the output current and the output voltage at a user specified interval.

The remote monitoring system shall have the facility to interrupt the coupon to pipe connection and measure the instantaneous off potential. This may be done based on a remote or local user request or based on pre-set intervals.

1. Remote Monitoring and Control

The remote monitoring system shall be capable of the following as a minimum:
Monitoring and control of pipe potential, output current and output voltage, it shall also monitor incoming AC supply voltage, mode setting and door open alarms.
It shall be capable of activating a solid state relay to interrupt the coupon/pipe connection measuring the potential of the coupon at a user specified period after interruption. This action may be set to occur at a pre-set interval or may be requested at any time by a remote or local user.
Within the boundary of Rand Water stations and booster stations the interface shall be fibre optic cable with MODTCP connection to the Ethernet network. It shall transmit all relevant data at a user specified interval via the Ethernet connection to the Rand Water Wonder Ware server.
The remote monitoring system shall have battery back-up for hourly data transmission for 48 hours
A data receiving unit c/w GPRS modem and all necessary drivers shall be installed at the Rand Water Scada server
The receiving unit and all associated hardware shall be capable of hosting up to 50 TRU's as standard.
The server software shall be configured to receive and display the data as well as to produce monthly summary management reports
The monthly management reports shall as a minimum report the following key performance indicators:
Percentage "Up Time",
Average "on" pipe potential,
Average "off" pipe potential,
Percentage time within specified range for "off" and "on" pipe potentials, average output current and Voltage and Maximum and minimum output current and voltage.
Data sheet of the equipment to be installed in the TRU including details of I/O functionality
Data sheet of the equipment to be installed at the Scada server
Details of any drivers to be supplied to enable communication between the remote monitoring system and the Scada server
Statement of alarm management philosophy
Statement of exception reporting philosophy

2. Electrical Specification

2.1. Power Transformer

The transformer shall be a step down, double wound power transformer requiring a 230V, 50Hz or 400V, 50Hz supply.
The transformer rectifier unit (TRU) voltage output shall be 100V/100A and the forced drainage unit (FDU) shall be 150A/100V with the bypass diode of 600A or 300A (as specified in the Bill of Quantities).
The Power Transformer is double wound and continuously rated in accordance with BS 171. Or, IEC 60076 Parts 1 to 5. The Power Transformer has an earth screen between the primary and secondary to intercept voltage transients.

2.2. Rectifier

The Rectifier Bridge shall consist of six silicon thyristors, Semikron or equivalent, connected for full wave rectification, which shall be rated at twice full load current and 1600 PIV. The thyristors shall be rated for continuous operation of 120ºC and are to be mounted on aluminium heat sinks suitable for convection cooling. Forced cooling is not permitted.
IEC 60140 – Semiconductor Converters
Output control shall be by means of a digital three-term PID closed loop feedback controller.
The controller shall have a LCD display that will display the mode setting, the set point potential and the measured actual potential.
Details shall include:
Data Sheets of the controller
A method statement on how the proportional, integral and differential control modes will be utilised to achieve optimum feedback control functionality.

2.3. Meters

The TRU shall include the following meters:

(1) AC Voltmeter for the measurement of the incoming AC supply voltage
(2) DC Voltmeter for measurement of Rectifier voltage
(3) DC Ammeter for measurement of Rectifier current
(4) DC Voltmeter for measurement of Pipe potential shall be integrated into the controller's display

All meters are to be suitably labelled.
The DC Rectifier voltmeter is to be analogue and shall have a glass fuse in each lead. The DC ammeters are to be analogue and connected up to the DC CT.
All analogue meters shall be 96mm square with an accuracy of 1,5% of maximum reading. The controller display shall be 96mm wide.
The DC meters are to have captive female terminals (banana jacks), coloured red and black, for checking the appropriate measurements. The ammeter shall indicate the value of the shunt.

All meters are to be flush mounted such that the housing is insulated from the mounting plate.
All the DC meters shall have their leads connected to a single multi-pole "press to test" push button switch such that a reading on the meters is obtained only when the switch is pushed in, and automatically disengages upon release of pressure. The switch must engage/disengage both leads to each meter.

2.4. Surge Protection

Surge protection shall be installed as described below
Moving away from the rectifier bridge towards the output terminals, surge protection is sequentially installed as follows: -
Two off Dehn VM 275 or equivalent, are connected in series between positive and negative legs. Between the two VM 275 devices, a connection to the earth bar is made via a Dehn VM 275. In addition to the above, a Dehn VM 600 or equivalent, in parallel is connected between the positive and negative legs. This is followed by 0.5mH Choke in the negative leg.
Followed by:
Between positive leg and earth, two parallel Dehn VM 150 MOV in series with a Dehn Ex-FS (120kA) spark gap with Cu-W electrodes. Between the two Dehn VM 150 and the spark gap described above, a Dehn Ex-FX (120kA) spark gap is connected to the negative leg. All spark gaps have Copper Tungsten electrodes.

2.5. Wiring and Busbars

Multi-strand cable shall be used.
Joints or splices in any wiring are not permitted. Not more than two conductors shall be connected to any one terminal.
All conductors shall be numbered at both ends with reference to the Schematic Wiring Diagram supplied.
All conductors excluding busbars shall be routed in trunking or harnessed.
Busbars shall be aluminium or tinned copper. The latter shall be tinned after cutting, forming and drilling. Tinning shall be in accordance with Grade Sn6C of BS 1872.
Busbar joints shall be bolted and the mating surfaces coated with petroleum jelly or a similar water-repellent paste prior to assembly.
Bolted joints shall be provided with spring washers. Fasteners on aluminium busbars shall be tinned or cadmium plated.
2.6. Colour Coding Labelling

The following colour coding shall be adhered to: -

DC Positive electrical cables	:	Red
DC Negative electrical cables	:	Black
Earth cables	:	Green
Cable for reference electrode	:	Red
Coupon	:	Black
Monitoring cable	:	Black

Electrical warning signs : Black on yellow background

All components and/or components assemblies shall be labelled.

Labels shall cross reference to the circuit diagram.

Labels shall be of the engraved "sandwich" type (trifoliate) with black letters on a white background except the positive output terminal label, which is in white letters on a red background.

Labels are in upper case letters with a height of 6mm for component labels and 10mm for output terminal labels.

Output terminals shall be labelled as follows: -

+ GROUNDBED

- PIPE

PIPE MON

REF ELECT

COUPON

EARTH

Cables shall be identified by means of permanently marked ferrules with black lettering on a white background.

Ferrules shall be slip-on-type and matched to the size of the cable.

Ferrules shall be situated so as to read right way up on horizontal cables and from lug to insulation on vertical cables.

2.7. Cable Ends and Terminals

Cables shall be terminated at each end by means of lugs.

Control cable lugs shall be pre-insulated or insulated by means of heat shrink sleeves.

Power cable lugs shall be insulated by means of heat shrink sleeves or slip-on rubber shrouds colour-coded as follows:

DC Positive (Groundbed) : Red

DC Negative (Pipe) : Black

All terminals shall be completely accessible after completion of all wiring.

Terminals on power connections shall be provided with lock nuts and washers.

Output terminals shall be fully insulated from the metal of the housing and will comprise of brass bolts, each provided with nuts, lock nuts, washers and tinned copper cable lugs suitable for the specified cable size.

The negative terminal shall be M10 and the positive terminal shall be M16.

Separate terminals size M6 shall be provided for the pipe monitoring cable, and reference electrode.

A 10mm diameter hole shall be drilled in the earth bar in order to facilitate connection via a lug to the earth cable.

2.8. Earthing

The surge diversion units shall be all connected to the common earth incorporating the primary AC supply earth, transformer screen and the transformer rectifier housing.

The common earth consists of 30 x 3mm tinned copper or 40 x 5mm aluminium busbar.

On installation, the common earth shall be connected to a local earth by means of two 35mm² copper cables.

All electrical circuits shall be floating with respect to earth.

2.9. Spares

The following spares shall be supplied with the TRU:

Fuses	:	Three of each type and rating used
MOV's	:	One of each type and rating
Spark Gaps	:	One of each type and rating

The spares shall be mounted a designated panel on the TRU frame.

2.10. Safety Devices

The TRU shall contain the following safety devices:

i) Circuit Breaker: -

This shall be matched as close as possible to the rating of the TRU output current, and is not merely be used as an isolation switch.

ii) Thermal Switch: -

A Thermal cut out switch shall be mounted on the rectifier heat sink assembly and automatically engage/disengage when the temperature goes above/below 85˚C, respectively.

iii) DC Fuses: -

The DC fuses shall operate before or when the output current reaches a value of 40% greater than the rated value and such that no damage shall be caused to any of the components or insulation.

Auxiliary AC Supply

The TRU shall be provided in the front and back with a standard 220V single-phase 16A three-point plug for providing power to auxiliary devices. An earth leakage device protects the auxiliary supply.

The three-point plug shall be connected to the input side of the main circuit breaker such that power shall be still available even if the main circuit breaker has tripped.

Mounting Frame

The TRU shall be mounted on a 304L stainless steel frame constructed from 50mm x 50mm square tubing. It shall include an instrument cabinet of internal dimensions 250mm deep x 500mm wide x 600mm high.

The door of the instrument cabinet shall have 96mm x 96mm cut-outs to accommodate the controller, the DC voltmeter, DC ammeter and the AC supply voltmeter.

2.11. Testing

The following tests shall be carried out at the Manufacturer's works in the presence of the Engineer. All equipment shall satisfactorily pass such tests and a test certificate shall be made available to the Engineer. All testing shall be carried out at the Manufacturer's expense.

Should the equipment fail any of the tests, the contractor shall be given 48 hours to rectify the non-compliances. Should the equipment fail a second time, Rand Water reserves the right to source the require equipment elsewhere. Costs associated with an alternative source will be for the contractor's account.

In the event that any of the tests detailed below, or the complete inspection, is waived, then this does not release the Manufacturer from his obligation to supply completely satisfactory equipment or warranted performance as specified, and to supply "type test" results from essentially similar units.

Short Circuit Full Current Test	-	A short circuit full current test to Prove current limit operation shall be carried out. In addition a full current test at 10% output voltage will be carried out to ensure stable operation and ripple compliance.
1000V Megger Insulation Test	-	The TRU shall withstand a 1000V Megger insulation test from primary to secondary, primary to earth, DC positive to earth and DC negative earth
Efficiency Test	-	Efficiency tests were carried out at 20%, 60% and 100% of maximum current at full rated voltage.
Potentiostatic Control	-	Contractors shall submit details of their proposed testing method to demonstrate adequate control in the presence of an external fluctuating DC influence

Instrument cabinet shall have 96mm x 96mm cut-outs to accommodate the controller, the DC volt meter, DC ammeter and the AC supply volt meter.

TS002 ANODES SUPPLY

Anodes are to be tubular MMO 19mm diameter x 1000mm length with loading of 200 A-year.

The details are as follows:

Type	:	Tubular
Substrate	:	Titanium
B338 Grade 1		
Activation	:	Iridium/Tantalum oxides, by multipass thermal decomposition
Operating Environment	:	Soil
Design Life	:	20year20 years
Tail	:	Factory made connection - 16mm^2 HMWPE Sheath / Kynar Insulation,

Anodes are to be supplied with certificates demonstrating compliance with the following:

Resistance	:	Anode to cable resistance <0.0010Ohm
Insulation	:	Cable Insulation no defects at 15kV
Coating	:	Uniformity checked by non-dispersive X-Ray Fluorescence
Electrochemical	:	Test -200A/m^2 for 30 minutes
Voltage Drop	:	No significant increase in driving voltage
Coating Defects	:	No visible defects

The number of anodes required and the lengths of the anode tails are given in the bill of quantities.

Each anode is to be installed inside a 2000mm long x 200mm diameter x 1mm thick galvanized steel canister. These canisters are to be filled with calcined petroleum coke of the same specification as that of the rest of

the Ground-bed.

Each anode shall have a lifting lug attached to the inside of the bottom cap of the canister. A support rope (10mm polypropylene) of the same length as the anode tail shall be attached to this lifting lug and then be brought through the top end cap via a suitable PVC gland. The cable shall exit the canister through a separate adjacent gland.

TS003 CONCRETE BUNKER SUPPLY

The overall height of the bunker prior to installation shall be no less than 1.4m.

The minimum wall thickness in any part of the bunker shall be 250mm. The door shall be a lockable concrete lid that provides extreme protection against vandalism of bunkers. It shall have no exposed hinges and a flushed key hole to prevent vandalism. The flushed key shall be so well protected inside the tube to render it inaccessible.

The lid shall fit into a 3CR12 steel frame that is cast into the concrete roof bunker wall. The frame shall be supplied to the contractor who then shall position it into place at the time of fixing the reinforcement ensuring the centre of the lid is an access tube that goes all the way through to the lid which then gives passages to the locking mechanism.

The locking mechanism shall follow a three step mechanisms consisting of an access tube, a plug, a multilevered key with a gear lock capable of being changed to produce different keys with each installation of keys. The key shall not be reproducible for many numbers of doors.

The concrete door shall be preferably 500 x 400mm for easier lifting but it shall not be more than 500mm x 500mmIt shall be made from 60 MPA concrete and shall have multi layers of reinforcing bars that are so closely spaced as to render it effectively chisel proof. The various components and locking mechanism shall be made from stainless-steel. The installation shall be conducted as per TS022.

TS004 SUPPLY OF PERMANENT REFERENCE ELECTRODES AND COUPON

Housing	:	Porous ceramic 135mm diameter x 305mm high
Element	:	16mm^2 spiral copper conductor (total length of conductor inside housing shall be a minimum of 2m)
Medium	:	copper sulphate crystals in saturated copper sulphate gel (110mm diameter by 220mm high)
Seal on housing	:	Primary cement cap and secondary epoxy resin Cap.
Cable Tail	:	single core copper 16mm^2 red PVC/PVC to be joined to a 10mm^2 extension cable where necessary
Pre-packaged bag	:	Cotton bag approximately 195mm diameter x 460mm long.
Chemical backfill	:	75% hydrated gypsum, 20% Bentonite, 5% sodium Sulphate.
Accuracy	:	+/- 10mV over 15A (<3 micro-amp load)
Stability	:	0ºC to 55ºC

The details of the coupon are as follows:

Bare metal area	:	50mm by 50mm.

Coating	:	Twin Pack epoxy (Denso ST85 or equivalent).
Cable connection	:	Single 16 mm^2 black PVC/PVC Pin brazed and encapsulated in epoxy
Isolation from pipe	:	6mm neoprene rubber.
Attachment to pipe	:	Suitable adhesive such that coupon may not be dislodged during backfilling.

TS005 TRANSFORMER RECTIFIER UNIT, FORCED DRAINAGE UNIT AND NATURAL DRAINAGE UNIT INSTALLATION

1. Delivery installation

The contractor shall collect free issue TRU's from Rand Water or supply TRU's as per TS001 if specified in the bill of quantities and deliver them to the construction site. The delivery and installation of TRU's shall be as soon as the Durasafe Enclosure installation is complete.

2. PRE and Coupon

For every TRU installation the PRE and coupon shall be installed as per TS014 and the additional cables there of as per TS021.

3. Cabling

Positive, negative, coupon, and PRE cables are to be connected to the pipe as per TS015 and channelled for termination in the TRU as per TS019. The Positive, Negative, PRE, Coupon and AC cables shall be terminated to the appropriate terminals on the TRU via appropriate lugs. AC cables are to be installed via the isolation box to the TRU where they will be terminated to the appropriate terminals.

4. Isolation Breaker Box

The isolation breaker box should be supplied and mounted on a stand inside the Durasafe enclosure which is to be constructed and installed as per attached figure 1. The TRU shall be earthed as per specified below:

5. Earthing System

The earthing system of the TRU, will comply with the following basic requirements:
A 70mm^2 BECW1 main ring conductor will be installed around the TRU to which bonding leads will be connected. This earth ring will be installed at 800mm depth.
One (1) earth spike will be installed at each of the four (4) corners and two (2) in the middle of the main earth ring. Earth spikes are not to be spaced more than 10m apart.
Each spike will be installed in a water meter box and protected by a 110mm sleeve. The spike will be visible inside the 110mm sleeve, but will be at 300mm depth.
The measured earth resistance of the main earth ring to ground should be less than 10Ω. The main earthing

ring will interconnected with any existing earth network installed on the site in at least two (2) places.
Bonding connectors will be 70mm^2, Cu/PVC (green/yellow PVC).
Bonding connectors will be protected with a 20mm galvanised steel pipe from ground level to the level of the earth boss on the unit. These protection pipes will be installed from the ground to connection point.
Bonding connector will be connected to the TRU by means of the earth boss (M8) welded to the unit.
All earthing connections will be done by fusion bond or cat welded.
The TRU will be earthed at two (2) opposite points.
Bond connections to the main earth ring will not be spaced more than 5m apart.
Certificate of Compliance (COC)
Upon completion of installation of the TRU a qualified Master Electrician shall issue a COC for the TRU to effect connection to the live side.

TS006 ACQUIRING CATHODIC PROTECTION SYSTEM SERVITUDE

1. Land and Rights

The Contractor shall appoint a land and rights specialist to collect cadastral data, survey records from the surveyor general and verify the owners details with the Deeds office on proposed CP sites; the data shall then be used by the specialist to prepare the cadastral drawings that they will use to conduct the negotiations and way leave application for recommended CP sites with the respective land owners. The specialist shall collect the valuation report and standard Rand Water infrastructure agreement form from Rand Water and shall make sure that all the land agreements are signed and initialled in each page by the land owner after every successful negotiation. If the Land owner put forward any conditions in addition to the agreement then such conditions shall be communicated with the Rand Water Land and Rights Manager before the agreement can be signed. The Specialist shall hold regular meetings with Rand Water Land and Rights to report on progress.

TS007 CONSTRUCTION OF A VERTICAL DEEPWELL ANODE GROUNDBEDS

The bore holes shall be drilled by a professional drilling contractor registered with the Borehole Water Association. Tenderers are to submit details of the company they intend to use for this activity.

A 20cm diameter borehole shall be drilled at the Groundbed position as per drawing RA23994 Rev1. This hole shall be made available to the Engineer for testing purposes. A CP engineer will perform suitability test on the pilot hole for a Deep Well and there after compile a report containing findings and recommendations to be discussed with Rand Water Engineer.

The contractor shall await the Engineer’s approval after which drilling of the main borehole may proceed.

A PVC casing of suitable length shall then be installed at the month of the bore hole to prevent the bore-hole form collapsing. The casing shall protrude at least 300mm above natural ground level.

The Engineer shall witness the entire anode Groundbed installation.

TS008 CONSTRUCTION OF SHALLOW VERTICAL GROUNDBEDS

The contractor shall await the Engineer's instruction to proceed with Groundbed construction.

The Groundbed shall consist of shallow vertical holes drilled or augured to a maximum depth as specified in the BOQ at a diameter of 200mm installed at "BOQ to specify" depth of cover and spaced "BOQ to specify" apart. Each hole with a maximum of 3 anodes spaced 1.5m from centre to centre with individual tails being terminated inside the anode junction box as per drawing RA23994 Rev1. A PVC casing of suitable length shall then be installed at the month of the bore hole to prevent the bore-hole form collapsing. The casing shall protrude at least 300mm above natural ground level

The Engineer shall witness the entire anode Groundbed installation.

TS009 VERTICAL ANODE INSTALLATION AND BACKFILL

The contractor shall Supply Mixed Metal Oxide (MMO) Anodes without canisters as per TS002 if specified in the bill of quantities or collect free issue material from Rand water and deliver them to the construction site.

At least 2m bottom portion of the Groundbed is to be filled with calcined petroleum coke of particle size 100% <1.5mm and 5% <0.5mm before start of active zone.

Anode shall be installed centrally in the active zone inside the calcined petroleum coke bed. Anodes shall be spaced 1.5m from centre to centre with individual tails being terminated inside the anode junction box. The coke shall be mixed with soapy water (liquid soap) to form slurry prior to pumping or pouring inside the bore hole. No dry coke shall be allowed. The top anode shall be covered with at least 1m coke bed.

The remainder of the Groundbed or inactive zone is to be backfilled with graded washed silica sand of particle size 5-7mm with quantities indicated in the drawing accompanying the tender document.

TS010 ANODE JUNCTION BOX

The contractor shall supply concrete bunkers as per TS003 if specified in the bill of quantities and deliver them to site.

A concrete bunker shall be installed on top of the anode Groundbed in the case of a deep well and at a position indicated by the Engineer in the case of shallow vertical Groundbeds. The anode tails shall enter the anode junction box via an HDPE conduit. The positive cables from the TRU – as per TS021– shall also enter via an HDPE conduit.

The anode tails and the TRU positive cables shall be terminated on a tinned copper or aluminium bus bar as per drawing number 17302. This bus bar shall be rated to 50A. The bus bar shall be mounted inside the enclosure by means of insulated stand-offs.

TS011 INSTALLATION OF INTERFERENCE MITIGATION FACILITY/FOREIGN CROSS BOND

The contractor shall collect free issue Concrete Bunker from Rand Water or supply concrete bunker as per TS003 if specified in the bill of quantities and deliver to the construction site. The delivery and installation of Concrete Bunker shall be as soon as the Concrete Bunker foundation construction is complete. The installation of the Concrete Bunker shall be as per TS022. The Contractor shall supply and install 16mm^2 PVC/PVC insulated as required and attach it to the pipe as per TS015. The contractor shall supply and install 0-2 Ohm 100W variable resistor.

The interference test shall be done between Rand Water (or Contractor) and the affected party.

TS012 INSTALLATION OF MONITORING FACILITY

1. Concrete Monitoring Cabinets

The contractor shall collect free issue Concrete Bunker from Rand Water or supply concrete bunker as per TS003 if specified in the bill of quantities and deliver to the construction site. The delivery and installation of Concrete Bunker shall be as soon as the Concrete Bunker foundation construction is complete. The installation of the Concrete Bunker shall be as per TS022. The Contractor shall supply and install 16mm^2 PVC/PVC insulated black cable in quantities as indicated in the Bill of Quantities and attach it to the pipe as per TS015. The lugged ends of the above cables shall be terminated in the bunker by means of a linked panel. Reference drawing is 17302 just for a single pipeline. The contractor shall Paint the concrete bunker blue as per SANS 731-2:2006 and label it on the outside with the relevant pipeline code.

2. Valve Chamber Test Points

Chamber mounted monitoring studs are to be installed at valve chambers. Connection between the monitoring stud and the pipe is to be done by means of 16 mm^2 PVC/PVC insulated black cable. Cable to pipe connection is to be conducted as per TS015.

TS013 INSTALLATION OF CROSS BONDING FACILITY

The contractor shall collect free issue Concrete Bunker from Rand Water or supply concrete bunker as per TS003 if specified in the bill of quantities and deliver to the construction site. The delivery and installation of Concrete Bunker shall be as soon as the Concrete Bunker foundation construction is complete. The installation of the Concrete Bunker shall be as per TS022. The Contractor shall supply and install Bonding 35mm^2 PVC/PVC insulated black cable in quantities as indicated in the Bill of Quantities and attach it to the pipe as per TS015. The lugged ends of the above cables shall be terminated in the bunker by means of a linked panel. Reference drawing 17302. The contractor shall Paint the concrete bunker blue as per SANS 731-2:2006 and label it on the outside with the relevant pipeline code.

TS014 PERMANENT REFERENCE ELECTRODE (PRE) AND COUPON INSTALLATION

The Contractor shall collect free issue of PRE and Coupons from Rand Water or supply PRE and Coupons if specified in the bill of quantities and deliver them to the construction site. The Coupon shall be installed at the 9 o'clock or 3 o'clock position. Reference drawing RA_27374. The PRE shall be installed in no less than 30cm away from the pipe at the 9 o'clock or 3 o'clock position.

The Contractor shall where necessary extend the PRE and Coupon cables by means of appropriate Ferrules and Splicing kits and install the above cables as per TS021.

TS015 CABLE TO PIPE CONNECTION

Cable to pipe connections shall be by pin brazing. The technique used shall ensure that metallurgical contact is achieved between the cable and the pipe. Contractors shall submit details of the equipment to be used.

The minimum amount 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.

Apply squish pack Hi-Cote 151E epoxy or equivalent over the repair area, ensuring a minimum 5mm cover over the cable connection. A minimum overlap of 50mm shall be made over the existing coating.

All cable to pipe connection and coating repairs shall be witnessed by the Engineer.

TS016 CONTINUITY BONDING OF BURIED JOINTS

Buried pipe joints shall be continuity bonded by means of 2 off 16mm^2 black PVC/PVC insulated copper cables pin brazed to either side of the joint and then follow the TS015 and TS019 procedure.

TS017 CONTINUITY BONDING INSIDE VALVE CHAMBER

Valve chambers shall be continuity bonded by means of 1 off 35mm^2 black PVC/PVC insulated copper cables pin brazed to either side of the valve chamber (as per TS015) refer to layout drawing number 17300.The cable shall be run through a 20mm diameter PVC conduit mounted with saddles 200mm above the top of pipeline along inside wall of the chamber.

In the presence of water inside the chamber, the contractor is required to drain all water within the chamber. The contractor is also required to supply their own machinery and equipment in performing the water drainage. The drainage equipment should be placed outside the chamber at all times for safety precautions.

TS018 CONTINUITY BONDING OUTSIDE VALVE CHAMBER

The cables are to be laid around the outside of the chamber walls at a depth of 1000mm for the outside pump stations pipelines

Valve chambers shall be continuity bonded by means of 2 off 35mm^2 black PVC/PVC insulated copper cables pin brazed to either side of the valve chamber as per TS015.Excavation and reinstatement as per TS019.

TS019 SERVICE DETECTION, EXCAVATIONS, TRENCHING AND BACKFILLING

The Contractor shall ensure that all excavations are carried in accordance with SABS 1200 and all items stipulated below

Excavations shall only be carried out once all services have been identified and proved by hand. Any excavations over the pipelines shall be carried out by hand.

Trenches for cable runs shall be to a minimum depth of 600mm as per SANS ISO155891: 2003 E unless otherwise as directed by the Engineer. Any excavation of depth 1m or more shall be shored as required by the construction regulations.

Compaction of excavations shall be to a density of at least 90% of the modified AASHTO maximum dry density.

The Contractor shall provide a density gauge. This density gauge with operator shall be made available to the Engineer for use if and when required.

Any paving, roads, damage to foreign services etc. shall be reinstated by the contractor to original condition to the approval of the owner. The Engineer will inspect all excavations prior to backfilling.

TS020 ENCLOSURE INSTALLATION

The contractor shall supply a precast concrete slide door vault in the shape of a U which allows the control panels to be accessed from both sides, this unit shall house the TRU as specified in TS001. The delivery and installation of slide door vault shall be a week after the completion of the U shaped slide vault foundation construction.

Prior to U shaped slide vault installation, excavate, prepare the foundation area and compact it as described in TS019.

The slab shall have dimensions prescribed by the manufacturer but not be more than 6.5m long by 2.5m wide and 250mm thick as per drawing RA23430. 110mm diameter cable ducts shall be installed such that AC and earthing cable may be brought to the isolator box mounted on the inside floor of the U shaped slide vault (this duct shall extend to the edge of the slab) and then from the isolator to a position under the TRU. In addition a separate 110mm diameter cable duct shall be installed such that positive, negative, reference, and monitor cables may be brought to a position via the TRU frame (this duct shall extend to the edge of the slab).

The walls and roof slab shall be 200mm thick and made up of heavily reinforced 60MPA concrete.

The locking mechanism of the vault shall consist of padlocks securely fitted in the locking channel, the second step if the access tube shall have a plug, multi levered keys with a gear capable of being changed after a few installations. The door shall slide open easily owing to the three steel wheels and slide easily into the embedded concrete base.

The contractor shall Paint the concrete Durasafe as per SANS 731-2:2006

TS021 CABLE INSTALLATION

Prior to Laying of cables, excavation of the trench in which the cable is to be laid should be as per TS019. The length of the trench should be as specified in the BOQ. All cables shall be concrete encased as per drawing 27376

AC cable: Shall be 1 off 16 mm^2 PVC/PVC four core galvanised steel armoured black cable. There should be a safe separation distance between AC cables and other cables in the same trench of 300mm.

Positive Cable: Shall be 2 off 35 mm^2 PVC/PVC four core galvanised steel armoured black cable.

Negative cable should be 2 off 35 mm^2 PVC/PVC single core black copper cable.

Monitoring cable should be 1 off 16 mm^2 PVC/PVC single core black copper cable.

PRE cable should be 1 off 16 mm^2 PVC/PVC single core red copper cable.

Coupon cable should be 1 off 16 mm^2 PVC/PVC single core black copper cable.

An openable electric cable sleeve to prevent damage to four core red copper cable.

Cables connecting each AC mitigation wires to the monitoring bunker shall be green/yellow 35mm^2 PVC/PVC cables.

All cable routes shall be marked with concrete cable marker blocks at intervals of 20m as well as at bends.

The PRE and Coupon cables when necessary should be joined with an appropriate cable joint connecting splice kit.

TS022 CONCRETE BUNKER INSTALLATION

Prior to Concrete Bunker installation excavate, prepare the foundation area and compacted as described in TS019. A foundation of dimensions 1m x 1m and 100mm thick shall be cast as per the layer works in the drawing RA25573 l. Two 50mm diameter cable ducts shall be installed such that they obtrude through the centre of the foundation and extend to the edge of the surround.

The contractor shall supply the bunker and deliver to the construction site. The delivery and installation of Bunker shall be a week after the completion of the Bunker foundation construction.

After the bunker has been placed on the foundation a surround shall be cast around the bunker with dimensions of 2m x 2m. The surround shall be 100mm thick at the point where it meets the bunker wall and shall have a 25mm fall toward the outer edges to allow for rain water drainage.

Painting of the concrete bunker to be as per SANS 731-2:2006in a blue colour. The mix of 40MPA strength to fill the inside of the bunker to just below the door level.

The bunker surround shall contain 200mm by 6mm reinforcement mesh.

The concrete cube strength at 28 days shall be 60MPa. Maximum coarse aggregate size shall be 19mm.

TS023 COMMISIONING THE CP SYSTEM

1. Energising and Balancing of the System

Upon completion of the installations electrical certificates of compliance shall be issued prior to energizing.

The system shall be energized in the potentiostatic mode and balanced such that “on” potentials are not more negative than -3V. IR free as well as “on” potentials shall then be determined at all available test posts.

2. Measurement of IR Free Potentials

These tests shall capture the “on” and “off” coupon potential values for a 24-hour period each at a minimum interval of 1s.

Contractors shall submit a methodology with their tenders including full details of equipment to be used.

The acceptance criteria shall be as follows:

Off potential : More negative than -0.95V

On Potential : Most negative limit of -3V.

Should any adjustment of the TRU or cross bond settings be required, the entire system shall be re-tested.

3. Measurement of “ON” Potentials

These tests shall capture the “on” potential values for a 24-hour period each at a minimum interval of 1s.

Contractors shall submit a methodology with their tenders including full details of equipment to be used.

4. Interference Testing

- These tests are to be carried out jointly with foreign pipeline owners and the CP Engineer. Procedure to be agreed upon with foreign pipeline.
- Carry out 24hrs potential recordings on Rand Water and Foreign Service pipeline with no bonds connected. Recordings to be done up to 2km either side from the crossing (bond) on both pipelines.

- Connect bond at crossing.
- Determine the magnitude and direction of current flow in the bond.
- Set- up data logger at the bond to measure current and potential.

Carry out the following:

- Switch off Rand Water TRU's (either side of bond) for one hour.
- Switch on Rand Water TRU's for one hour.
- Switch off Foreign Service TRU for one hour.
- Switch on Foreign Service TRU for one hour.

- Analyse data, discuss and reach mutual agreement with Foreign Service owner regarding suitable resistive bond.
- The Rand Water commissioning engineer shall determine mitigation measures mutually with foreign pipeline owner/ CP representative.
- All measurements to be recorded

TS024 CLOSE INTERVAL POTENTIAL SURVEY (CIPS) or (CIS)

This survey will require one mobile data logger and two static data loggers.

Current interrupters will be installed at all DC current sources as well as at the pipe/coupon connection of the test post on either side of the section being tested. The switching cycle will be 800ms/200ms On/Off.

The current interrupters and the data loggers shall be synchronized by means of GPS.

Static data loggers shall be installed at test posts on either side of the section to be surveyed. These tests shall capture the "on" and "off" coupon potential values for a 24 hour period each at a minimum interval of 1s.

The On and off measurements shall be made while walking directly over the pipeline. Measurements shall be taken at least every one meter (1m) with an Off value being recorded at least every 5m.

Position measurement shall be by means of a surveyor's wheel as well as by GPS. GPS coordinates shall be recorded on the mobile data logger while surveying. (Reference NACE SP0207-2007 and SANS15589-1 preamble).

The current drainage test shall be done at a strategic position to locate the TRU's location by injecting the current to the pipeline by the use of a portable rectifier or battery bank to check the CP spread along the pipeline. This test is normally used to determine the rating of the rectifier per specific pipeline protection.

TS025 SOIL RESISTIVITY SURVEY

- The soil resistivity shall be measured by the 4-pin Wenner method.
- Soil resistivity measurements are to be carried out at 100m intervals with pin spacing of 1m and 2m and 3m.
- All measurement locations shall be captured on sub-metre accuracy GPS.
- Tenderers are to submit full details of the equipment to be used.
- Supply a detailed report of the survey results.

TS026 ANODE GROUNDBED SURVEY

The following factors should be considered:

- The availability of power supply.
- Purpose of the groundbed and availability of servitudes.
- Minimum of 100m away from the pipeline.

Soil resistivity shall be measured using 4-pin Wenner method at incremental pin spacing of 2m.

Horizontal : 2m to 12m

Shallow vertical : 2m to 30m

Deep well vertical : 2m to 100m

All measurement locations shall be captured on sub-metre accuracy GPS.

Supply a detailed report of the survey results.

TS027 ANODE GROUNDBED SURVEY (VERTICAL ALTERNATIVE)

The following factors should be considered:

- The availability of power supply
- Purpose of the groundbed and availability of servitudes.

DC Multi-electrode soil Resistivity Surveys for should be conducted for sub surface imaging across all the traverses before the drilling and trenching process can commence.
A minimum of 64 electrodes should be used and the following taken into consideration:

- Traverse aerial photo.
- Minimum electrodes spacing of 7m.
- Maximum electrode spacing of 147m.
- Covering depth of approximately 70m
- Supply a detailed report of the survey results

All measurement locations shall be captured on sub-metre accuracy GPS

TS028 QUALITY CONTROL AND ASSURANCE PLAN

Tenderers shall submit a sample quality control plan with their tenders.

After contract award, the successful contractor shall submit within 2 weeks a detailed quality control plan (QCP) and Method Statement (MS) for the project.

The plan shall take into account the following minimum Rand Water requirements:

TS029 ENCLOSURE (METERING KIOSK) INSTALLATION

The contractor shall supply and deliver a metering kiosk enclosure (as shown in figure 3) to site Prior to Enclosure installation excavate, prepare the foundation area and compacted as described in TS019. A foundation of dimensions 1.8 m x 1.5 m and 200mm thick shall be cast 100mm below ground level. Two 110mm diameter cable ducts shall be installed such that they protrude through the centre of the foundation. The isolation breaker box should be supplied and mounted on a stand inside the enclosure which is to be constructed and installed as per attached figure 1.

TS030 FINAL DOCUMENTATIONS AND SYSTEM HAND OVER

Two copies of the operating and maintenance manual for the CP and AC Mitigation system shall be submitted by the contractor.

- Data Packs

The format of the data packs that will be handed over as part of the final document hand over of the pipeline will be agreed between the engineer and the contractor. The contractor will provide the engineer with a sample hand over pack for review and approval, before competing this task. The CP contractor will supply a data pack index to the engineer within 1 month of award. The index will then be agreed upon between the engineer and the contractor, and it shall consist of the following document:

- Supply commissioning report.
- Supply DCVG report as per ECDA NACE SP0502-2010.
- Supply CIPS report (if applicable).
- Supply As built drawing
- Supply equipment drawings.
- Supply equipment manuals.
- Supply operations and maintenance manuals.
- Supply training.
- Supply DGPS coordinates of all installations.
- Supply cable schedule

TS031 CATHODIC PROTECTION ENGINEER

A Cathodic Protection (CP) engineer shall have the responsibility of executing the work according to specifications TS023, TS030, TS032 and TS033.

TS032 ALTERNATING CURRENT (AC) MITIGATION

A CP engineer will conduct AC interference investigations and there after compile a report containing findings and mitigation recommendations to be discussed with Rand Water Engineer shall be conducted as per NACE SP0177-2007. The contractor will then implement the recommendations above upon Rand Water's approval.

All pipelines crossing or running parallel to overhead powerlines with the rating greater or equal to 88kV should be investigated by the contractor. Rand Water will provide the shape files of the Eskom Powerlines to the successful Contractor.

1. Gradient Control Wires

Zinc Ribbon gradient control wires are required to be installed in the specified chainage of the pipeline route.

The details are as follows:

Gradient control wires will be connected to the pipeline through solid-state decoupling devices (SS-DCD), see below.

The composition of the zinc will be as per ASTM B418 – 95 – Type II.

The zinc wire geometry will be of the "standard" dimensions as follows:

- 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
- Core wire diameter : 3.3 mm
- Potential : -1.1 V vs CSE
- Capacity : 780 Ah/kg

The gradient control wire, where required, shall be installed in the corners of the trench. A minimum lateral separation distance to the pipeline of 200 mm shall be maintained. In the case of a single gradient control wire, the wire shall be installed in either corner of the trench. The gradient wire shall be covered with either native soil (sifted if necessary) or with a gypsum / bentonite mixture, prior to the bedding material.

The gradient control wire shall compromise of discrete sections of up to 400m in length (as stated in the BOQ). The ends of successive sections shall not be in direct contact.

AC mitigation stations shall be utilized in housing the DC coupling equipment between the pipeline and zinc ribbon. The AC mitigation station compromises of a standard Rand Water concrete bunker as specified under TS003.

2. Valve Chamber Earth Mats

The external mat should be installed at 500mm deep from the natural ground level. The precast rings used to form the chamber floors are not earthed. Continuity of the floor reinforcing is established with a central bar at right angles welded to each bar, or by including a weld mesh layer cut to the floor size, above the structural re-bar.

The internal measures required for the structural concrete chambers are;

- Central floor rebar welded at each crossing,
- Continuity ring installed just below roof height and welded to each vertical rebar.
- Ring connected to pipeline through a voltage limiting device (VLD) with at least two connections, cables kept short as possible (≤ 1m).

External measures required at the chambers are:

- Install gradient mat extending to at least 1.2 m around the chamber, comprising 200mm x 200 mm x 6 mm diameter steel weld mesh, not galvanized, at any convenient depth greater than 0.3 m,
- Where required, weld mesh sections overlap by at least 100 mm, connect with at least two (2) crimped ferrule connections,
- At least two (2) cable connections to the weld mesh,
- Weld mesh encapsulated centrally in 85 mm or thicker concrete layer, 15/19 MPa,
- Cables enter chamber through a 20 mm diameter hole, sealed with grout after cable installation,
- Use VLD to connect the weld mesh to the pipeline using at lease all cables kept as short as possible (≤ 1m).
- All cables kept short as possible (≤ 1m).

For the air valves, the chamber is situated above the pipeline. In this case the contractor shall install the external mat at the same depth as the chamber floor. The pre-cast rings used to form the chamber walls are not earthed. Continuity of the floor reinforcing is established with a central bar at right angles welded to each bar, or by including a weld mesh layer cut to the floor size, above the structural re-bar.

The external and internal steel may be connected to the same VLD unless for any reason, different materials or encasings are used (e.g. zinc, or galvanized steel), in which case the external and internal mats require individual VLDs to prevent the formation of a galvanic cell.

3. Decoupling Devices

Gradient control Wires

The zinc ribbon shall not be connected to the pipeline directly but only through a solid state DC decoupling device.

A DC decoupling device is required for each ribbon length or pair of 200m or 400m connected near the centre of (+/- 50m). The sections shall not be in direct galvanic contact at the ends. DC decoupling devices should provide a low impedance AC path under both steady state and short circuit conditions, whilst blocking DC within a specified voltage range.

The device shall be certified by a suitably accredited test laboratory to meet the specifications given in the table below:

Specification/Test	Level/ Requirement	Comment
1) Class I impulse current rating	10 kA, 10/350 µsec	to SANS 61643-1 requirement
2) Front of wave spark-over voltage	≤ 500 V, 1.2/50 µsec	to SANS 61643-1 requirement
3) Rated AC short circuit	3.7kA r.m.s., 1 sec, 50 Hz	to SANS 61643-1 requirement
4) Rated AC load current	45 A r.m.s., 50 Hz, max temp incr. 40°C	at maximum DC blocking voltage, to SANS 61643-1 requirement
5) AC impedance	≤ 0.04 Ohm	at rated load current
6) DC blocking voltage	-12V/+1V(+/- 10%)	allows for DC traction
7) DC leakage (blocked)	≤ 1 mA	at AC load thermal limit
8) DC current withstand	60A for 15 mins	without overheating, test in both directions
9) Housing dielectric withstand voltage	5.8 kV	to SANS 61643-1 requirement
10) Environmental, enclosure	IP68	Allows for submerged chambers
10) Ambient temperature range	-15˚C to 60˚C	-
11) Air clearance and creepage	10 mm, 15 mm min resp.	to SANS 61643-1 requirement

distances		
12) Protection against direct contact	no direct contact	using IEC60529 test finger

Additional requirements for the DC decoupling are:

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

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

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

d) The capacitor and diode network shall be protected by a suitably rated SPD for high voltage and lightning-induced transients. This shall include the appropriate inductance to decouple the SPD from the diode stack, in accordance with SANS 61312-3.

Valve Chamber Earth mats

The gradient control mats, valve chamber reinforcing steel or retrofit internal gradient control mat shall not be connected to the pipeline directly but only through a voltage limiting device. The decoupling devices used for zinc ribbon, shall conduct AC or DC *only* on overvoltage and shall remain open circuit during steady state conditions.

A low-voltage, solid-state surge protection device shall be used for this purpose. The device shall be certified by a suitably accredited test laboratory to meet the specifications given in table below:

Specification/Test	**Level/ Requirement**	**Comment**
1) Class I impulse current rating	10 kA, 10/350 µsec	to SANS 61643-1 requirement
2) Front of wave spark-over voltage	≤ 500 V, 1.2/50 µsec	to SANS 61643-1 requirement
3) Response time	≤ 25 nsec	
4) Short circuit withstand	10 kA r.m.s., 1 sec, 50 Hz	to SANS 61643-1 requirement

5) Housing dielectric withstand voltage	5.8 kV	to SANS 61643-1 requirement
6) AC clamping voltage	75 V r.m.s (+/- 10%)	
7) DC breakdown voltage	100V (+/- 10%)	
8) DC leakage (blocked)	≤ 1 mA	
9) Environmental, enclosure	IP68	
10) Ambient temperature range	-15˚C to 60˚C	-
11) Air clearance and creepage distances	10 mm, 40 mm min resp.	to SANS 61643-1 requirement
12) Protection against direct contact	no direct contact	using IEC60529 test finger

4. Cabling

25 mm^2 and 16 mm^2 insulated copper earth cables (Cu/PVC) shall be used respectively for connection of DC decoupling devices and voltage limiting devices to the pipeline. The copper earth cables shall have a green and yellow colour combination and shall be doubled so as to provide redundancy.

The cable to zinc connections shall compromise of suitably sized ferrules crimping the cable connection to the anode core wire, silver soldering and use of an approved, self-vulcanizing butyl rubber tape to cover the joint area.

The cable to steel connections shall comprise exothermic welded joints. The cable to pipe connections shall be to specification TS015.

5. Isolating Flange Protection

PCR-3.5KA/80A-S-CS2 or equivalent,

PCR devices will be installed inside the valve chambers.

6. Cathodic Protection Monitoring Points FOR AC Induced Pipelines

All cathodic protection monitoring points along the pipeline are to be of dead front construction ZapGard or equivalent.

A dead front test point shall be constructed in such a way as to ensure that no metallic parts are exposed to a person on the operating side of the equipment. Contact should only be possible with insulated measuring probes. Appropriate operating instructions and a warning of the hazard shall be printed adjacent to the measurement points. Access to the live side should only be available to trained personnel and such access is to be controlled by means of locking mechanisms with keys being held by a senior authorised person. Device to be installed inside Rand Water reinforced concrete bunker enclosure.

TS033 CATHODIC PROTECTION DESIGN

The CP design Engineer should conduct and analyse the CP data including but not limited to stray current, current drain survey, soil analysis and compile a detailed CP design report considering Rand Water's free issue material specification. The CP design shall be as per NACE SP0169-2007, taking into account the conditions prevalent in the area concerned.

TS034 ELECTRICAL ISOLATION OF CATHODICALLY PROTECTED PIPELINES

The Insulating Flange shall be supplied and installed on the on the pump outlet flange and the inlet pipeline to the station, as well as both flanges of the mag flow meter.

The contractor is required to size and procure the isolation flanges as per requested installation. The installation and testing should be done as per DRG No. A 9548.

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

Flanges shall be hydraulic tested in factory to 1.25 times the flange classification or by the use of TINKER and RAZOR equipment. The type 2 flange sets shall not leak at field test pressure.

The assembled insulating joint shall be tested as follows for electrical discontinuity.

A) Place a free floating compass on top of the insulating flange. The needle will align parallel to the pipeline.

I) Bridge the two sides of the insulating joint with either a 12 volt heavy duty car battery or welding generator. If the insulating flange is not functioning the compass needle will deflect to a position orthogonal to pipeline. If the insulation joint is functioning correctly, the needle will flow across the joint should not exceed 50 amps.

II) Should a faulty insulating joint be located then the faulty materials shall be replaced and the joint system re-tested.

III) It is recommended that each bolt be tested for non-continuity before tightening thereof. The same must apply when a joint is tested and found to be continuous. The faulty bolts must be noted.

B) The final deflected position of the compass needle to be noted, i.e. The stabilized position and not the initial movements.

Flange machining flanges and finishes to Rand Water DRG A11791.

The mating flanges shall be drilled in pairs and marked.

Where mating flanges are to be welded on site, the flanges shall be bolted up with at least 3 fitted bolts and aligned properly before welding.

Inspection of insulating joints: after installation, the insulating joints must be inspected to ensure compliance with the specifications and drawings and their efficiency tested for satisfactory electrical insulation a stated above. The inspection shall be witnessed by the engineer or engineer's representative of the cathodic protection installation and the contractor.

Insulating sleeves: the maximum gap width between inside faces of steel washer and ends of insulating sleeve to between 2 to 3 mm, respectively, at any end before tightening. A 1mm gap may be left between the sleeve end and the steel flange where studs are required at valve connections.

TS035 DIRECT CURRENT VOLTAGE GRADIENT (DCVG) SURVEY

This survey will require a full DCVG survey equipment set include temporary rectifier systems, if there is no permanent CP system.

Current interrupters will be installed at all DC current sources on either side of the section being tested. The switching cycle will be 900ms/450ms Off/On.

The current interrupters shall be synchronized by means of GPS.

The location of defects shall be made while walking directly over the pipeline. Measurements of the size of the defect shall be taken at every defect using remote earth. All the pinpointed defects on a newly build pipeline shall be repaired before the Contractor leave site, and on the old pipelines, risk based approached shall be applied.

Position measurement of the defect shall be by means of a surveyor's wheel as well as by GPS. GPS coordinates shall be recorded on the mobile data logger while surveying.(reference SP0207-2007 and TM0109-2009 and SANS15589-1 preamble).

TS036 POWER SUPPLY FROM UTILITY COMPANY

The contractor shall apply as per power requirements to the Electricity utility company (EUC) in the area where the electricity point/s is/are required and then arrange a meeting with the EUC representatives on site to show

them the precise location of the required electricity point/s. The contractor shall then receive the contract for the required electricity from the EUC then submit it to Rand Water for vetting. Upon approval by Rand Water the contractor shall then pay the deposit to the EUC for the installation of required Electricity point/s.

TS037 CONSTRUCTION OF AN ELECTRICAL KIOSK

The kiosk shall be constructed next to the municipality or any other power utility company powerlines pole; the kiosk shall be enclosed in a 35 mPa concrete structure a lockable steel door built to meet the following dimensions.

Structure: Above Ground (Height = 1450 mm, Breadth = 340 mm and Length = 550 mm).

Lockable Steel Door (Height = 300 mm, Width 250 mm)

Two cable entry pipe shall be used, one for supplier and the other for consumer with the minimum diameter of 50 mm

Foundation dimensions shall be by 1500 mm x 500 mm and 250 mm thick and shall be cast at 150 mm below ground level and two cable entry pipes shall be installed such that they extend beyond through the center of the foundation. Please refer to figure 3 Town council electrical department drawing.

TS038 HORIZONTAL DRILLING AT ROAD CROSSINGS

A topographic survey shall be conducted before any drill can take place to investigate and identifying of the sub surface conditions including the underlying utilities and the soil conditions at the site. The contractor shall measure the width of the road to determine the length of the drilling in meters and thereafter obtain the permission from the servitude owner to start the work.

The minimum depth of the drilling should not be less than the required /minimum drilling depth as deemed acceptable by the road, rail/ servitude owners' .All the works should be witnessed by Rand Water Quality Assurance officers.

TS039 STRAY CURRENT SURVEY

The presence of stray currents and the magnitude shall be assessed prior to the installation of the pipeline and after the installation. Acceptable input impedance data loggers shall be used with the sampling rate of at least one value in every 5 seconds for a minimum duration of 24hrs.

TS040 CONTROLLED BLASTING

Applicable where the geotechnical investigations for the pipeline route have indicated that blasting may be expected on significant portions of the total pipeline length. This section covers the principal requirements of the Contractor wherever blasting takes place.

40.1 Management of Risks

The Contractor will, prior to commencement of blasting operations, conduct hazard identification and risk assessments related to all the drilling and blasting processes. Strategies to deal adequately with the risks will be developed and submitted to the Engineer.

In addition to baseline risk assessments, issue based and continuous risk assessments should be carried out during the period of the contract.

The strategies adopted must ensure that damage does not occur to the surrounding pipelines and there will be no resultant loss of water. The Contractor will be liable for all damages to services caused as a result of the Contractor's negligence.

40.2 Standard Procedures

The Contractor will, prior to commencement of blasting operations, develop and submit to the Engineer their standard procedures for conducting the total blasting and/or rockbreaking procedures for the following areas:

- Control of explosives
    - Handling, transport and storage
    - Security of explosives/initiating systems
- Drilling
- Use of explosives
    - Blast layouts/designs/volumes/explosives and initiating systems
    - Priming
    - Charging
    - Stemming
    - Timing and connecting
    - Firing procedures
- Treatment of misfires
- Destruction of explosives

It is a requirement of this contract that the Contractor is fully competent in the processes associated with blasting trenches in close proximity to other services and accepts responsibility for the development and implementation of these procedures.

The Engineer reserves the right to submit these procedures for specialist review and call for a re-examination of the procedures where significant deficiencies are identified.

40.3 Environmental Blasting Aspects

The Contractor will take into account in the development and application of the designs and procedures, the various impacts on the environment.

40.3.1 Determination of safety zones during blasting

The Contractor will evaluate and demarcate safety zones for each blast and take measures to minimize/control fly-rock so as to prevent injury to people and animals as well as damage to equipment and services.

It is expected that it will be necessary to provide cover for the majority of the blasts.

40.3.2 Air Blast (Sound-over-pressure)

The accepted levels for air blast will be applied, i.e.

- 128dB – reasonable level for public concern (no more than 10% of measurements to exceed this value)
- 134dB – damage should not occur below this level (no measurements to exceed this value outside the safety zones for each blast).
  Thus it will be necessary to take regular measurements, particularly in the early stages of blasting to establish benchmarks, which can be reviewed based on performance history.

40.3.3 Ground Vibrations (Peak Particle Velocity and Frequency)

It is expected that it will be necessary to conduct test blasting in the various site specific conditions such as areas adjacent to steel pipes and/or asbestos concrete pipes as well as sections of “elastic” rock properties and/or rocks with higher uniaxial compressive strengths, e.g. dolerites.

In these instances, it will be expected that results will be obtained of blasting efficiencies and excavation stabilities, but it will also be necessary to conduct vibration analysis at strategic points.

From several results, it will be possible to determine the range of site specific constants in the equation to estimate peak particle velocity, distance from blast and maximum charge per delay, i.e.

$$\text{PPV} = a\left(\frac{D}{\sqrt{E}}\right)^{b}$$

PPV in mm/sec (peak particle velocity)
D in metres (distance from blast)
E in kg (mass charge per delay)
A site characteristic (intercept with y axis)
B site characteristic (gradient on line)

In addition, the frequency of ground vibrations will be measured. Damage to structures can be expected in the range of 5-25Hz. Whilst these lower frequencies are regularly achieved in surface mining and quarrying, they are less common in construction/civil blasting but should be protected against.

40.3.3.1 Services

The initial blast designs should aim to produce less than 5mm/sec (ppv) and greater than 25Hz at the closest pipeline(s) to the blast.

However, trial blasting may indicate the need for higher factors of safety with a lower ppv.

In the higher risk areas of asbestos concrete pipes and live/operational pipelines it is recommended that use be made of electronic initiating systems to eliminate the variations encountered in pyrotechnic initiating systems.

Other forms of rock breaking may have to be considered and utilized at no extra cost to the client.

40.3.3.2 Buildings and other structures

Vibration measurements will be taken at strategic buildings and structures and measures put in place to ensure the South African guidelines are not exceeded: (greater than 50Hz)

Blast Situation	**Recommended Maximum Level mm/s**
Heavily reinforced concrete structures	120
Property owned by concern performing blasting operations	84
Commercial property in reasonable repair	25
Private property – public concern (blasting frequent/regular)	10

Notwithstanding these guidelines and limits, the Contractor will at all times be responsible for the safety of the works, persons, animals, equipment, property and services in the vicinity of the blasting operations.

It is expected that the Contractor will obtain photographic evidence plus other measurements of buildings and structures prior to blasting taking place. It will be the responsibility of the Contractor to make good at his own expense any further damage to houses, buildings, structures, services which have resulted from this blasting.

40.3.4 Occupational Hygiene (Blasting)

Adequate precautions should be taken to minimise exposure to:

- Blasting fumes (nitrous oxides, carbon monoxide, etc.)
- Airborne pollutants (dust)
- Water pollution (nitrates)

The limits expressed in Chapter 22 of the Mine Health & Safety Acts Regulations should be used as occupational exposure limits.

40.4 Statutory Compliance

40.4.1 Acts and Regulations

The Contractor must ensure his staff are fully cognizant of the current legislation and processes must be in place to ensure compliance.

In addition to the requirements of the Explosives Act No. 15 of 2003, it is notified that new Explosives Regulations under this Act are due to be promulgated shortly.

These regulations impose additional duties and administrative burdens including revised applications for licenses, permits, certificates, authorizations and written permissions. In particular, certain employees will require Police Clearance Certificates. This includes the appointment of a legal person – Explosives Supervisor/Manager – to be responsible for the control and use of explosives.

In addition to the relevant regulations, the Contractor must conform to the relative SANS standards particularly regarding the use of initiating systems.

The Contractor will supply the Engineer with copies of all the relevant blast permits, licenses and authorizations prior to commencement of blasting operations.

40.4.2 Competence

The Contractor will ensure that all his personnel involved in the blasting processes have been trained and assessed competent to perform their assigned duties.

Copies of related certificates, training undertaken as well as work experience will be provided to the Engineer for all employees involved with the blasting processes, both on and off site, prior to start of blasting operations.

40.5 Blasting Operations

Prior to starting any drilling for blasting operations, the Contractor shall submit the blast plan to the Engineer indicating details of the drill holes (diameter, depths, inclinations, directions, sub-drill) as well as the blast pattern/design (burden, spacing, charge details, stemming, pattern, timing, powder factor, mass charge per delay).

These should be indicated on sketches and/or tables with additional information on the geology as required (weathered zones, voids, presence of water).

The Engineer may submit these plans for specialist review, more particularly in cases where change takes place and/or anomalous conditions exist.

The Engineer will then agree a programme (dates and times) for the blast(s) to be conducted.

Whenever blasting operations consistently approach agreed limits and/or the safety factors are reduced to the extent that damage with serious implications could occur, the Engineer reserves the right to order the Contractor to modify his methods and procedures of drilling and blasting or other Rockbreaking techniques without invalidating this contract.

The Contractor shall have no claim for extra payment, over and above his tendered rates, due to being instructed to modify the methods and procedures of drilling, blasting and Rockbreaking regardless of any prior acceptance of procedures submitted to the Engineer.

Within 24 hours of each blast, the Contractor will submit to the Engineer, the actual data related to the blast including the volumes of rock blasted.

In the event of any non-conformances, e.g. misfires, fly-rock, excessive ground vibrations, gassing, damage/injuries to persons/equipment/structures/services, these will be reported to the Engineer or his representative immediately.

TS041 CONSTRUCTION WORK NEAR HIGH VOLTAGE POWER LINES

The contractor shall appoint a competent person who will be responsible for electrical safety, who will conduct a risk assessment taking all prevailing site conditions into account. All personnel working under a high voltage (HV) alternating current (AC) affected area should undergo basic training in safety precaution measures to be undertaken when working therein. Caution! Should there be a storm during any work under or near high voltage AC power systems all work should cease and personnel hasten to a safe distance from the power systems.

All temporary grounding connections on pipeline spools should be left in place until immediately prior to backfilling. Temporary grounding connections should be made of copper ground rods, bare pipe casing, or other appropriate grounds. Cables used for bonding to the grounding facilities should be of good mechanical strength and have electrical conductivity equal or high than that of the grounding conductor. The structure to cable to grounding facility connection should be made with clamps that apply pressure and also have conductivity equal or greater than that of the grounding conductor.

Vehicles and other construction equipment are subject to electrical safety regulations where operated in the vicinity of AC power lines and therefore should be grounded as well. Other metallic structures such as temporary shed, trailer, fences or other structures that are subject to AC influence should be grounded.

Field Practice

The electrical safety person shall:

1. Make sure that the movement of equipment tools and the offloading of pipelines is carefully co-ordinated.
2. Make sure that supervisors and workers know the location of all the electrical power sources in the work area before starting work.
3. Accurately determine the load current, voltage and minimum distance limit of approach by contacting the owner of the high voltage AC power system.
4. Review the minimum distance limit of approach with everyone on the high voltage AC affected work site. A pre-work safety awareness meeting should be held and written records of the meeting and attendance kept.

5. Make sure that there are temporary electrical grounding facilities at intervals of no greater 300 metres apart. Extra care should be taken when working in low resistivity soil (i.e. wet soil conditions) conditions.
6. Make sure that all temporary grounding connections on pipeline spools should are left in place until immediately prior to backfilling.
7. Temporary grounding connections should be made of copper ground rods, bare pipe casing, or other appropriate grounds.
8. Cables used for bonding to the grounding facilities should be of good mechanical strength and have electrical conductivity equal or high than that of the grounding conductor.
9. The structure to cable to grounding facility connection should be made with clamps that apply pressure and also have conductivity equal or greater than that of the grounding conductor.

TS042 CONSTRUCTION OF HORIZONTAL GROUNDBED

The contractors shall Supply Mixed Metal Oxide (MMO) Anodes as per TS002 if specified in the bill of quantities or if not specified collect free issue material from Rand water and deliver them to the construction site.

The Groundbed shall consist of a number of anodes arranged horizontally at a specified distance away from the pipeline with spacers between them as per drawing RB-22675.The depth of the anode trench shall be at 2 meters from the natural ground level, the bottom part of the Groundbed shall be filled with calcined petroleum coke between depth 200m and 500mm, selected backfill (calcined petroleum coke) between 700mm and 1000mm and backfill between 1000mm and ground level as specified in the drawing RA22675 accompanying the tender document.

TS043 INSTALLATION OF CROSS BONDING FACILITY IN THE EXISTING BUNKER

The Contractor shall supply and install bonding 35mm^2 PVC/PVC insulated black copper cable as indicated in the Bill of Quantities and attach it to the pipe as per TS015. The lugged ends of the above cables shall be terminated in the existing bunker by means of a linked panel. Reference drawing 17302.

TS044 CONCRETE INSTALLATION ON UNDERGROUND CABLES

Prior to Laying of cables, excavation of the trench in which the cable is to be laid should be as per TS019 and drawing RA-25785. The length of the trench should be as specified in the BOQ. The cables shall be laid at the bottom of the trench suspended approximately 10 cm above trench surface by means of wrapping on the steel cages at intervals of 5 meters to allow for the complete cable encasement. Thereafter the 35 MPa concrete mixes shall be applied on top of the cable for the width of 50 cm, height of 50 cm and the entire length of the trench and subsequently be allowed time to cure. At the end of the process compacting shall be done as per TS019 and drawing RA-25785 of this technical specification.

TS045 NATURAL DRAINAGE UNIT (NDU)

The Natural Drainage unit (NDU) shall consist of a surge diode, together with fuses, chokes, ammeter, disconnecting link and surge protection devices. From the pipeline terminal, a bus-bar shall connect to the diode anode via a series shunt, while the diode cathode is connected to the rail bus-bar via a fuse. A 3000H 500A choke is to be installed in each of the pipe and rail legs. Pullout links are required in each of the output legs. An ammeter and shunt are to be installed von the protected side of the surge protection devices.

1. Surge Protection

Between the pipe and the rail legs before the two chokes, two Dehn vm130 or equivalent in parallel shall be connected in series to a spark gap, EX-FS (120kA) with copper tungsten electrodes or equivalent. Between the two Dehn VM130 and the spark gap a Dehn EX-FS (120kA) with copper tungsten electrodes shall be connected to earth.

On the other side of the chokes, two of Dehn280 or equivalent in series are to be connected between the pipe and rail legs. Between the VM280 devices a connection to the earth bar is to be made via Dehn VM 280 Next to the above, a Dehn VM 500 or equivalent, is to be connected between the positive and negative legs

2. Component rating and characteristics

Component	**Rating**	**Make**
Diode	600A3000PIV	Semikron SKN870 or equivalent
Wiring	600A	
Chokes	600A300H	
Disconnecting links	600A continuous 300A Load switching	
Fuse	600A or 300A	
Shunt	50mV/600A	
Ammeter	600A	

The temperature inside the cabinet may reach 60^0c. All components are to be rated for cooling under natural convention conditions.

Snubbing network comprising a disc ceramic capacitor, resistor and MOV are to be installed directly across the diode.

The ammeter shall be analogue, 96mm square with an accuracy of 1.5% of maximum reading. the two disconnecting links shall be of the knife action or the pull out type. (e.g. Fuse holder) suitable for the easy and

safe connection/disconnection of the circuit.

3. Spares

Component	Nr	Component reference
Spark Gap	1	Dehn EX Cu W electrodes or equivalent
MOV	1	Dehn VM 130 or equivalent
MOV	1	Dehn VM280 or equivalent
MOV	1	Semikron SKV20 B420 or equivalent
Fuse	1	Fast acting
Diode	4	Semikron SKN B70/30 or equivalent

4. Mounting Frame

The NDU shall be mounted on a 304L stainless steel frame constructed from 50mm x 50mm square tubing

TS046 WIRE ANODES SUPPLY

Anodes are to be wire mixed metal oxide 1.5mm diameter and consist of solid titanium wire which meets ASTM B348 Grade 1or 2 standards as shown on the table below.

TYPICAL PROPERTIES		
Component / Property	**Test Method**	**Typical Value**
Copper Conductor		
Dimensions	ASTM B263	16mm^2 or 35mm^2
Longitudinal Resistance	ASTM B193	0.001 Ωm or 0.00045 Ωm
Mixed Metal Oxide Wire		
Wire Size (Diameter)	Measured	1.5mm
Wire Type	Internal	Solid Titanium ASTMB863 Gr 1
Maximum Current (20yr Life)	Internal	60 to 250mA/m
Petroleum Coke Backfill		
Bulk Density	ASTM D527	1200 g/l
Fixed Carbon	ASTM D3172	99.5%
Ash	ASTM D-4422-89	<0.5%
Jacket Material		
Material Type	Internal	Highly absorbent fabric sleeve
Diameter & Weight	Measured	40mm and 220g/m^2
Chlorine Resistance	Internal	8 months immersion - Passed

The anode wire shall be installed 300mm (on either side of the pipe depending on the pipe size and design) parallel to the existing pipeline with the length specified in the Bill of Quantities. The anode is installed either in the pipe trench or pipe servitude, at a depth of 1.5m to 2.5m, and for the whole pipeline length or part thereof.

Since the anode comes complete with coke, therefore it is simply unrolled and placed in the trench. Where bedrock is encountered, sifted soil should be placed below the anode/cable and similarly during backfilling, about 50mm of sifted soil should preferably be placed over the cable before proceeding with normal backfill.

The anode is rated at 50mA/m of cable and a life in excess of 40 years at this current level. The current output at any location will depend on the soil resistivity.

The longitudinal anode shall be supplied in multiple lengths of 100m up to 1000m, wound on wooden drums and for long pipelines, the anodes shall be brought up into the test point/ bunker or chamber at an interval of not more than 1000m for continuity monitoring. To acquire the intended distance, anodes shall be joined by the use of end cap kits or suitable splicing kits.

TS047 VANDAL PROOF CABLE INSTALLATION

Prior to laying of cables excavation of the trench in which the cable is to be laid should be as per TS019. The cable dimensions should be as stated under TS021. Deep trenches need to have good compaction, good visibility and line of site. The cables should to be installed in double track protection. Two tracks should be bolted and welded together with the cable sandwiched in the middle. Natural soil should then be used as backfill. Flat wrap razor should than be laid between 1000-1050m. The trench should be filled with backfill.

TS048 VANDAL PROOF HORIZONTAL ANODE GROUNDBED

The Groundbed shall consist of a number of anodes arranged horizontally at a specified distance away from the pipeline and shall have a spacing of 1000mm between them as indicated on drawing no. RB-22675. The depth of the anode trench shall be at 2 meters from the natural ground level, the bottom part of the Groundbed shall be filled with calcined petroleum coke between depth 700m, from 700m, flat razor wire with an early warning alarm system attached from 700-750m, natural soil backfill from 750- 1250m, rubble and stones from 1250-1500m and vegetable soil from 1500-2000m.

TS049 TRANSFOMER UNIT PROTECTION

The rectifier shall be installed inside the durasafe or the steel cabinet anti-vandalism housing (as specified in the Bill of Quantities).

A reinforce steel plate and locking mechanism should be installed inside the durasafe. The steel plate should be installed and bolted adjacent to the stationary durasafe up stand. The steel plate should be the same dimension as the up stand ensuring and enabling opening and closing efficiently.

A double skin fence or a Clearview should be installed around transformer to deny access to transformer. An anti-climb and anti-cut robust wire with weld joints and a dimension of (4.3 (breath) ×8.3 (length) × 2.4(height)) should be installed around the durasafe. The gate is to be installed the same height as the fence with a length of 2.4m. The gate should also be installed directly across the durasafe up stand to allow convenience of opening the durasafe. A razor wire should be installed around the double skin wire for extra protection. An infrared sensor alarm should be attached to the gate and should be able to detect if the gate is being tempered with.

TS050 REPLACEMENT OF BUNKER DOORS

The existing 304L stainless steel door must be removed and handed over to Rand Water. A bunker vandal proof retro door with same dimensions as the steel door should be installed on the existing bunker. The main components of the retro door should consist of a frame, bullet hinge, opening tool and a door assembly.

The locking mechanism shall follow a three step mechanisms consisting of an access tube, a plug, a multi-levered key with a gear lock which shall lock 4 ways upwards, downwards and both sideways capable of being changed to produce different keys with each installation of keys. The key shall not be reproducible for many number of doors.

TS051 REMOVAL OF EXISTING CATHODIC PROTECTION SYSTEM

Existing durasafe and TRU should be removed and stored safely. They should then be re-installed as per TS005 and TS020. An existing groundbed should then be linked to the re-installed TRU and the whole system tested and commissioned as per TS023.

A damaged durasafe should be removed and transported to Rand Water headquarters. A free issue durasafe will be supplied and installed as per TS020.

An existing damaged anode groundbed should be removed and the land should be prepared and groundbed should be installed as per TS042.

Damaged anode tails should be replaced and attached to the anode junction box as per TS010 and tested if they are fully functional.

Existing bunkers and anode junction boxes should be removed and safely stored. The bunkers should then be re-installed as per TS022 after construction and necessary cross bond connections done.

In completion of replacement of any damaged, a system assessment should be performed to ensure that the adequate corrosion protection is achieved on the pipeline.

TS052 SECURITY/PATROL DURING CONSTRUCTION

Personnel should be appointed to guard all generator powered sites for the duration of the contract. The patrolling should take place for 24 hours and 7 days a week.

TS053 SOLAR POWER ICCP SYSTEM

Provide for a complete off the Grid Solar Power solution that will be able to power Cathodic Protection System.

The system shall consist of:

- Install Solar Rectifier 24V 10A DCDC Rectifier in polycarbonate enclosure.
- Install Battery system Battery's Gel Deep cycle 12V 200Ah battery
- Charge controller
- Solar panel 300Wp 1983x997x42
- Install Solar panel on existing Concrete Durasafe.
- All cabling forming part of the solar solution including cabling from solar panels.
- Weather proof, well ventilated rodent and insect proof enclosure for batteries and controller.
- Vandal resistant structures and enclosures ensuring security of system.

Additional Requirements:

- Contractor shall provide all design drawings in Auto CAD version
- Contractor shall provide guarantees and all warrantees for all equipment
- Contractor shall provide for vandal proof system structure drawings (some structures might need to be signed off by a structural engineer)
- Contractor shall provide a performance guarantee for the system

TS054 TEMPORARY TRANSFOMER RECTIFIER POWER SUPPLY

The contractor is required to supply and operate a 3 phase generator which will be attached to the impressed current cathodic protection system, and also supply the fuel for the duration of the contract. The contractor is required to ensure that the generator is fully functional and operating 24 hours and 7 days a week. The generator should supply enough power to ensure that ICCP system is fully functional, and the contractor should ensure that the transformer rectifier unit is not damaged. The generator is required to be under full surveillance and 24 hour security as stated under TS052. The generator specification is as follows:

Rated frequency (Hz)	50
Min. output (kVA)	5
Max. output (kVA)	10.5
Rated voltage (V)	400
Rated current (A)	16 (AC)
Rated rotation speed (r/min)	3000
Phase number	Three-phase
Starting system	Electric starter
Fuel Type	Diesel

TS055 TEMPORARY SACRIFICIAL ANODE CATHODIC PROTECTION (CP) SYSTEM

The system shall be designed by a Corrosion Specialist with experience in cathodic protection for water pipelines. The Corrosion Specialist shall design the system to provide effective corrosion control in accordance with latest codes and standards: **NACE SP 0169: Control of External Corrosion on Underground or Submerged Metallic Piping System and SANS 15589: Petroleum and Natural Gas Industries – Cathodic Protection of pipeline transportation systems. Part1**:

The contractor is required to supply and install a 10Kg magnesium anode of the following dimensions (length and diameter) of a bag and backfilling of 595mm X 200mm respectively with the total weight of 22Kg to be used as a temporary sacrificial anode cathodic protection system. The SACP system shall be designed for a to be stand-alone system with a minimum life span of 10 years.

Temporary CP will be provided by hi-potential 10Kg magnesium anodes surrounded by gypsum/bentonite clay backfill in a cloth bag with $10mm^2$ Red PVC/PVC single core electrical cable. Preferably 2 and 4 anodes will be used per km for pipeline with diameter less than or equal to 1400mm and over 1400mm respectively as per drawing R0_27645 and RA_2764. The anodes will be connected to the pipeline at the closet valve chamber or monitoring point. The anode positions are to be GPS recorded by the contractor. The anodes must be disconnected once the permanent CP system is energised. Note: No anode will be connected directly to the pipeline. The anode cable is to be terminated in a link panel inside the chamber or monitoring post.

1. Component rating and characteristics of Magnesium Anode Alloys

ELEMENT	HIGH POTENTIAL ANODE
AL	0.010% max
Mn	0.5 – 1.3%
Si	0.05% max
Cu	0.02% max
Ni	0.001% max
Fe	0.03% max
Other (total)	0.30% max
Mg	remainder
Use	Soil and fresh water
Nominal potentials	-1.75V reference to copper sulphate

	reference electrode
Efficiency	50%
Capacity	1230 A-h
Consumption Rate	7.97Kg/A-Y

2. Galvanic Anode Backfilling

MAGNESIUM ANODE		
70%	Ground hydrated gypsum	CaSO4
25%	Powdered bentonite	clay
5%	Anhydrous sodium sulphate	Na2SO4

3. Diode Specification

In high stray current environment, magnesium anodes shall be connected via the diode so as to limit the amount of stray current to the pipe. Schottky barrier rectifier's 10 amperes 35 to 45 diode MBR1035, MBR1045 or equivalent shall be used as specified below.

Type Number	Symbol	MBR 1035 CT	MBR 1045 CT	MBR 1050 CT	MBR 1060 CT	MBR 1090 CT	MBR 10100 CT	MBR 10150 CT	MBR 10200 CT	Units
Maximum Recurrent Peak Reverse Voltage	V_{RRM}	35	45	50	60	90	100	150	200	V
Maximum RMS Voltage	V_{RMS}	24	31	35	42	63	70	105	140	V
Maximum DC Blocking Voltage	V_{DC}	35	45	50	60	90	100	150	200	V
Maximum Average Forward Rectified Current at Tc=125°C	$I_{(AV)}$	10								A
Peak Repetitive Forward Current (Rated V_R, Square Wave, 20KHz) at Tc=125°C	I_{FRM}	32								A
Peak Forward Surge Current, 8.3 ms Single Half Sine-wave Superimposed on Rated Load (JEDEC method)	I_{FSM}	120								A
Peak Repetitive Reverse Surge Current (Note 1)	I_{RRM}	1.0							0.5	A
Maximum Instantaneous Forward Voltage at: (Note 2) I_F=5A, T_C=25°C I_F=5A, T_C=125°C I_F=10A, T_C=25°C I_F=10A, T_C=125°C	V_F	0.70 0.57 0.80 0.67		0.80 0.65 0.90 0.75		0.85 0.75 0.95 0.85		0.88 0.78 0.98 0.88		V
Maximum Instantaneous Reverse Current @ Tc =25 °C at Rated DC Blocking Voltage	I_R	0.1								mA
@ Tc=125 °C (Note 2)		15		10		2.0				mA
Voltage Rate of Change (Rated V_R)	dV/dt	10,000								V/uS
Maximum Typical Thermal Resistance (Note 3)	$R_{\theta JC}$	1.5								°C/W
Operating Junction Temperature Range	T_J	-65 to +150								°C
Storage Temperature Range	T_{STG}	-65 to +175								°C

Notes:
1. 2.0us Pulse Width, f=1.0 KHz
2. Pulse Test: 300us Pulse Width, 1% Duty Cycle
3. Thermal Resistance from Junction to Case Per Leg, Mount on Heatsink Size of 2 in x 3 in x 0.25in Al-Plate.