DISA

ANODES (Pty) Ltd.
www.disaanodes.co.za

CATHODIC PROTECTION PRODUCTS

www.tuv.com ID:9105060137 TÜVRheinland
TÜVRheinland® CERT ISO 9001

INDEX

COMPANY PROFILE

Disa Anodes is an independent, privately owned manufacturing company employing 48 people and operating from a well equipped (4000m^2) factory in Johannesburg, South Africa. The company commenced operations in 1994, but its origins go back to 1978, when its predecessor company started Cathodic Protection contracting and installations.

The company exports its products to all five continents and has a European office to serve that area as well as North Africa and the Middle East.

Disa manufactures many and diverse products exclusively for the Cathodic Protection industry, and in order to do this efficiently and to a high standard, the company operates through a number of divisions, which are mentioned below (except for sales and administration).

Extrusion and Rolling Mill: It operates two extrusion presses, one of 1500 tons and another of 600 tons, each with associated equipment such as billet heaters, coilers, die ovens, run out tables, croppers, etc. Products include rod and ribbon anodes, with and without steel wire core, in various magnesium, zinc and aluminium alloys.

This division also operates a rolling mill for the production of rod and strip (<50mm) of the above alloys.

Foundry: This division has two zinc, three magnesium and one aluminium furnace, with a combined capacity of 300 tons, 100 tons and 50 tons per month capacity, respectively. Only virgin metal is used for melting and casting.

The foundry produces anodes of various shapes and sizes, as well as billets for the Extrusion Division.

Sacrificial Anode Finishing: This is where the pipeline anodes are fettled, fitted with a cable and bagged with a chemical backfill. Anodes for hot water tanks are also cut to size and fitted with an appropriate steel nut.

MMO Coated Titanium Anodes: The proprietary nature of the work excludes a description of the process and equipment. This division is nevertheless well equipped to produce anodes in the form of tube, rod, mesh, strip, and wire.

Accessories: Reference Electrodes, Grounding Cells, Spark Gaps and other allied products are manufactured in this unit.

QA Department: Disa Anodes is an **ISO 9001** accredited company and the QA Department is also responsible for the Laboratory. The latter has a Spectro spectrograph for chemical analysis of all cast products. Routine tests are carried out to evaluate the performance and conformance to specification of the various products. The Laboratory also carries out ongoing product research and development.

Concrete Yard: A variety of concrete products such as Test Posts, Marker Posts, Plinths, Route Markers, etc, are produced.

Mechanical Workshop: The company operates a well equipped workshop which serves various functions; these include maintenance, research, product development and improvement, production machining, etc.

We hope that you will find our products of interest; we are continuously improving and expanding our product range and please do not hesitate to contact us for your requirements, even for products that are not shown in the catalogue.

1. IMPRESSED CURRENT ANODES, CANISTERS & COKE

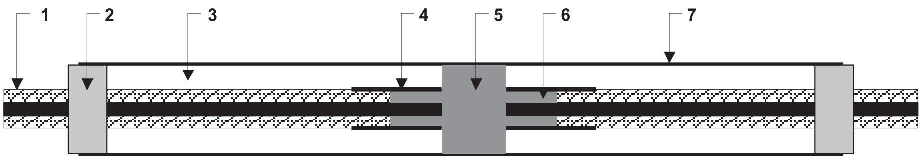
1.1 MMO TITANIUM ANODES

- Anodes are manufactured in the form of tube, wire, rod, strip, ribbon or mesh and used for the protection of buried or submerged pipelines, under and aboveground storage tanks, reinforced concrete and other buried metallic structures, as well as the inside of water tanks.
- MMO anodes are manufactured with Titanium metal (Grade 1 or 2) to ASTM B338 standard and active coatings consisting of Iridium and Tantalum Oxides and are suitable for both oxygen and chlorine evolution.
- Used with or without coke individually or in strings for horizontal and vertical groundbeds.

1.1.1 MMO Tubular Anodes

They are used to protect coated pipelines, underground storage tanks, and other buried steel structures for impressed current CP systems.

Disa Code	Anode			Life at Max Current			
	Length (mm)	Diameter (mm)	Weight (Kg)	Oxygen		Chlorine	
				Amps	Years	Amps	Years
C001	500	19	0.114	3	20	18	15
C002	1000	19	0.228	6	20	36	15
C003	500	25	0.155	4	20	24	15
C004	1000	25	0.310	8	20	48	15
C005	1200	19	0.273	7	20	43	15
C006	1200	25	0.372	16	20	58	15
C007	1500	19	0.342	9	20	54	15
C008	1500	25	0.465	12	20	72	15
Life is determined from tests in Sulphuric acid (Oxygen) and HCl acid (Chlorine)							



1.Double Insulated Copper Cable.

2.Rubber End Cap (1st Seal).

3.Cast Resin (2nd Seal).

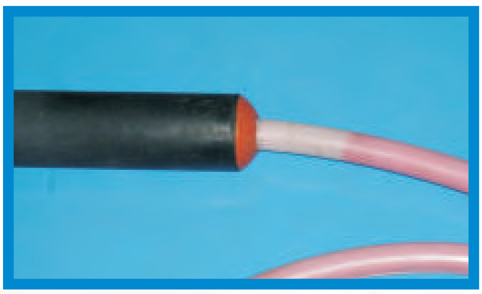
4.Heat Shrink (3rd Seal).

5.Titanium Insert forced into tube to ensure good electrical contact with the tube.

6.Titanium Insert crimped over Copper Cable. (<0.001Ω Res)

7.MMO coated Titanium Tube (0.9mm wall thickness.

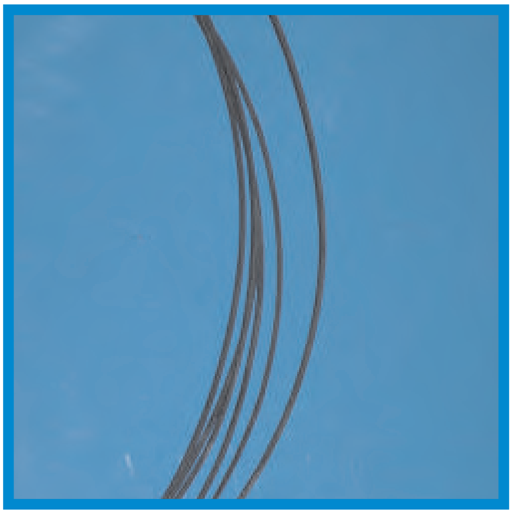
- Anodes are available individually or arranged in a string with PVC/PVC, XLPE/PVC, HMWPE/PVC, PVDF/PVC and PVDF/HMWPE/PVC insulated cable
- Minimum breaking strength of cable to anode connection:
  19mm OD > 960kg / 25mm OD > 1200kg



1.1.2 MMO Titanium Wire and Mesh Anodes

- ***Wire Anodes***

They are used to protect buried pipelines, underground and above ground storage tanks, and other buried steel structures. Wire anodes are available in coils of 100m long or in shorter lengths, up to 1.5m long. Long wire anodes are supplied with a parallel copper cable which connects the two.



Disa Code	Anode			Current Rating (mA/m)		Life (Years)
	Coil Length (m)	Diameter (mm)	Weight (kg/m)	GR	FW	
C005	100	1.6	0.009	50	500	20
C007	100	3.2	0.036	100	1000	20
GR = Soil FW = Fresh Water						

The shorter lengths can be put in a canister, while anodes of any length can be put in a cotton sock filled with petroleum coke.

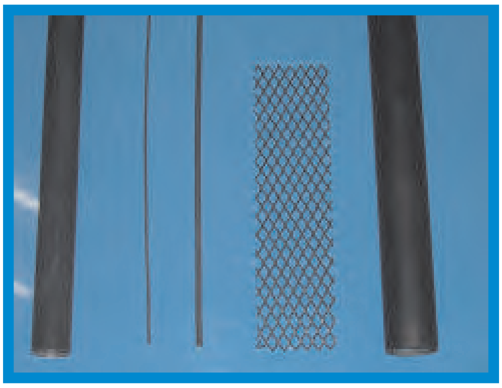
To Order:
Please quote the type and total length of the anode as well as the type and size of cable required.

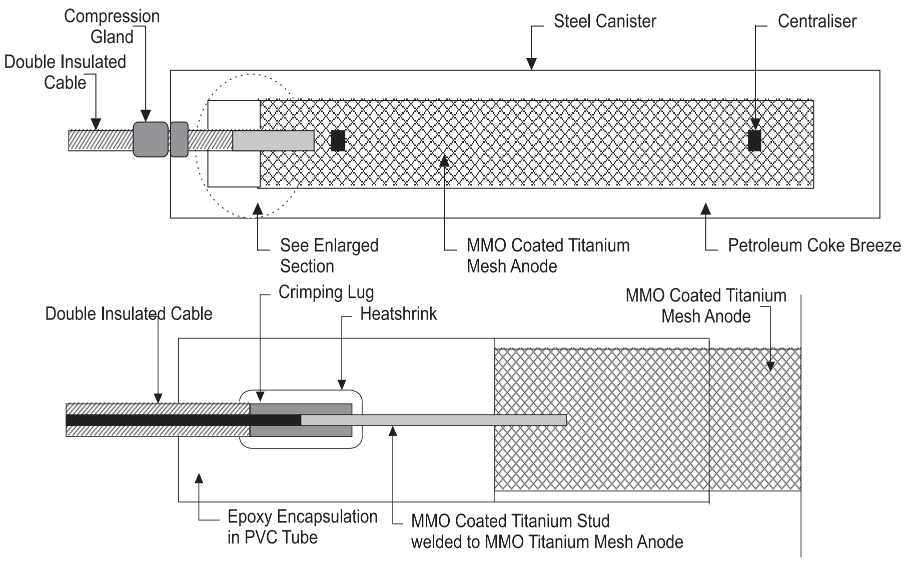
- ***Mesh Anodes***

They are used to protect buried pipelines, underground and aboveground storage tanks, and other buried steel structures. Diamond dimensions are 10 x 6mm.

Mesh Dimensions (mm)	Canister Dia. x Length (mm)	Weight of Anode, Canister and Coke	Anode Amp Years	Coke Amp Years	Current Amps
1 x 30 x 1220	150 x 1500	26	60	52	4
1 x 30 x 1220	150 x 2000	35	60	70	5.5
1 x 30 x 1220	150 x 1500	47	60	94	8

- MMO anode life is determined for fresh water
- Other canister sizes are available
- Maximum Current depends on soil resistivity





1.2. SILICON IRON ANODES

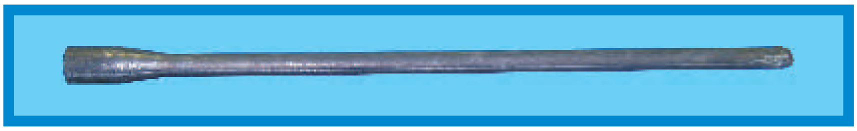
- Disa Anodes is a distributor of the Anotec chill cast range of tubular and stick type Silicon Iron (Si-Fe) anodes. They are used for the protection of buried pipelines, underground storage tanks and other buried metallic structures.
- Si-Fe anodes are manufactured to ASTM A518 Grade 3 standard with Si, Cr and Mn as main components.

Element	%
C	0.7 – 1.10
Mn	1.5 Max.
Si	14.0 – 17.0
Cr	3.2 – 5.0
Mo	0.20 Max.
Cu	0.5 Max.
Fe	Balance

1.2.1 Silicon Iron Anode (Stick or Rod Type)

They are preferably installed in horizontal anode groundbeds.

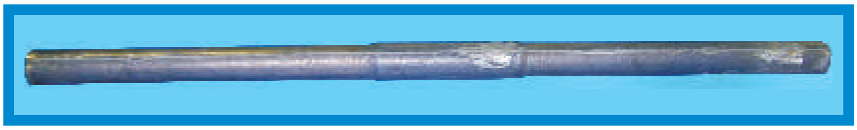
Disa Type	Nominal Dimensions (mm)		Nominal Weight (kg)	Nominal Area (m^2)	Current Rating (Amps)	Life Years
A001	51	1520	20	0.24	2.4	40
A002	76	1520	30	0.37	3.7	60



1.2.2 Silicon Iron Anode (Tubular Type)

- They are preferably installed in horizontal anode groundbeds and shallow vertical distributed anodes. Tubular anodes have central cable connection and therefore offer greater reliability.

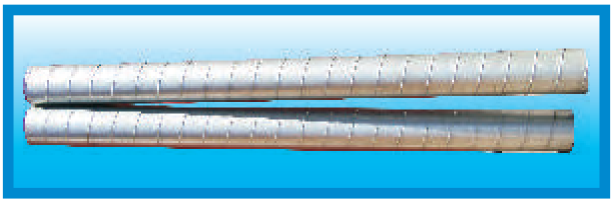
Disa Type	Nominal Dimensions (mm)			Nominal Weight (kg)	Nominal Area (m^2)	Current Rating (Amps)	Life Years
	ID	L	OD				
A003	66	1520	76	23	0.33	3.3	46
A004	56	2130	66	28	0.37	3.7	58



1.3 ANODE AND SPACER CANISTERS

- Impressed current anodes can be supplied individually or inside a coke filled steel canister. The layout and dimensions are shown in the table below.
- Spacer canisters are identical to the anode canister and contain only calcined petroleum coke. Spacer canisters may be ordered separately from the anodes.

Type	Size (mm)	Weight Coke Excl. Anode (kg)	Size (mm)	Weight Coke Excl. Anode (kg)
Anode/Spacer Steel Canister	100 dia. x 1500 long	12	100 dia. x 2000 long	16
Anode/Spacer Steel Canister	150 dia. x 1500 long	26	150 dia. x 2000 long	35
Anode/Spacer Steel Canister	200 dia. x 1500 long	47	200 dia. x 2000 long	63
Anode/Spacer Steel Canister	300 dia x 1500 long	106	300 dia. x 2000 long	141



Canisters

Coke

1.4 COKE

- Disa Anodes distributes petroleum coke locally manufactured by Sascarb. Two types are offered, Disa Coke and Corrcarb. Metallurgical Coke is also available.
- Petroleum coke protects the anodes from mechanical damage and reduces the resistance to earth of the groundbed.
- It also improves the performance and extends the life of the anodes.
- Disa Coke and Corrcarb have a bulk density between 1200 to 1250 kg/m^3 and is supplied in bags of 40kg.
- Coke is also supplied in steel canisters depending on the type and size of anode.

	Units	Metallurgical Coke	Disa Coke	Corrcarb
Fixed Carbon	Mass %	>85	>98	>99.5
Particle Size	mm	0-3 3-6 6-12	0-3 3-6 6-12	0-3 3-6 6-12
Bulk Density	Kg/m3	722	1250	1200
Bag Weight	Kg	40	40	40
Resistivity	ohm cm	0.43	0.06	0.05

2. SACRIFICIAL ANODES

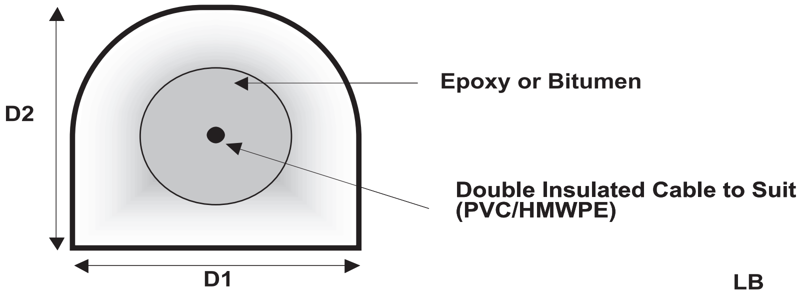
2.1 MAGNESIUM ANODES FOR BURIED PIPELINES AND TANKS

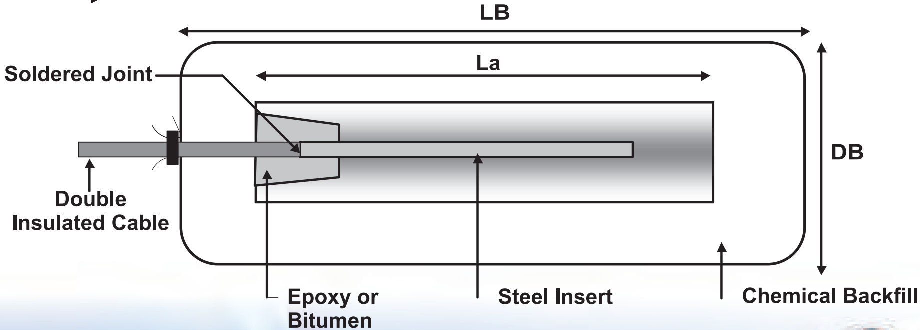
- Disa Anodes manufactures a range of cast and extruded magnesium anodes for the protection of buried pipelines, underground storage tanks and structures in areas where no stray currents are present.
- All anodes are manufactured from high quality primary magnesium, under strict quality assurance methods and are supplied with a quality chemical certificate.
  The Mg pipeline anodes are available in two compositions, corresponding to low and high potential.

Chemical Composition		
Element	**Disa Hi HPM**	**Disa Lo AZ63**
Al	0.01 max.	5.3 – 6.7
Mn	0.5 – 1.3	0.15 – 0.30
Cu	0.02 max.	0.02 max.
Ni	0.001 max.	0.003 max.
Fe	0.03 max.	0.03 max.
Zn	-	2.5 – 3.5
Others	0.05 max.	0.05 max.
Mg	Balance	Balance
Potential (V)	-1.7	-1.5
Capacity Ahrs/kg	1230	1200

- Low Potential anodes (Disa Lo) are recommended in soils with resistivities lower than 2000 Ohm m and High Potential anodes (Disa Hi) are generally used in soils with resistivities greater than 2000 Ohm m.
- They are supplied in various sizes bare or in a prepackaged chemical backfill composition of 70% gypsum, 25% bentonite and 5% sodium sulphate.
- The anode cable connection is achieved by soldering a copper cable to a steel insert in the anode.
- Cables offered are double insulated XLPE/PVC, PVC/PVC, HMWPE/PVC.

Disa Code	Anode			Bag & Backfill			Total Weight (kg)
	Length La (mm)	X Section D1 x D2 (mm)	Wt. (kg)	LB (mm)	DB (mm)	Wt. (kg)	
Hi/Lo 2.3	280	80 x 90	2.3	380	145	4.4	6.7
Hi/Lo 3.8	320	90 x 90	3.8	420	160	5.5	9.3
Hi/Lo 4.1	350	95 x 95	4.1	440	180	6.0	10.1
Hi/Lo 5.1	430	90 x 100	5.1	530	180	6.4	11.5
Hi/Lo 7.7	590	100 x 100	7.7	690	180	10.6	18.3
Hi/Lo 10.0	495	120 x 110	10.0	595	200	12.0	22.0
Hi/Lo 14.5	750	120 x 150	14.5	854	200	15.0	29.5
Hi/Lo 18.2	940	120 x 150	18.2	1050	200	19.3	37.5
Hi/Lo 21.8	1130	120 x 150	21.8	1230	200	22.0	43.8





2.2 MAGNESIUM RIBBON ANODE (with steel wire core)

- It is used to protect coated pipelines, underground storage tanks, and other buried steel structures in areas where no stray currents are present. Also used for the internal of water tanks.
- The anode is only available in alloy HPM-Disa Hi (1,7 V potential)
- Anode Details: 0.36kg/m by 19.05mm wide & 9,5 mm thick with 3,2mm diam. steel core.

How to order:
Note that this item is supplied in standard open coils of 100 and 305m in length. The total approximate weight of the coil is 36kg and 110kg respectively. Coil diameter is 1200mm.

Recommended procedure for connecting to copper cable:

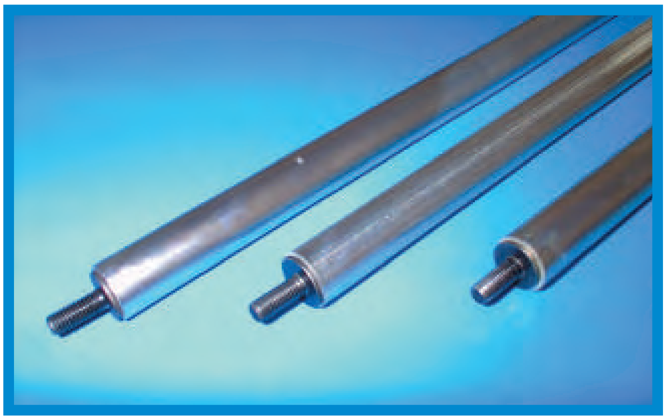
a) Using a hacksaw, cut the magnesium to the steel wire for a length of approximately 15mm.
b) Twist the cut Mg piece and remove from wire.
c) Fit tinned copper sleeve or ferrule over steel wire at one end and copper cable at the other.
d) Crimp and solder the connection
e) Fit heat shrink with sealant over the connection,

The steel wire may be exothermically welded or soldered to the steel structure

2.3 MAGNESIUM & ALUMINIUM ANODES FOR HOT WATER TANKS AND HEAT EXCHANGERS

2.3.1 Magnesium Geyser Rod Anode Alloy AZ31 and AZ63 with steel wire core

- They are used to protect the internal section of hot water tanks or geysers.
- They are supplied with a welded hexagonal nut or a threaded stud and washer, or without any fitting.
- This anode is also available in aluminium.
- Anodes supplied with 3,2mm steel wire core.



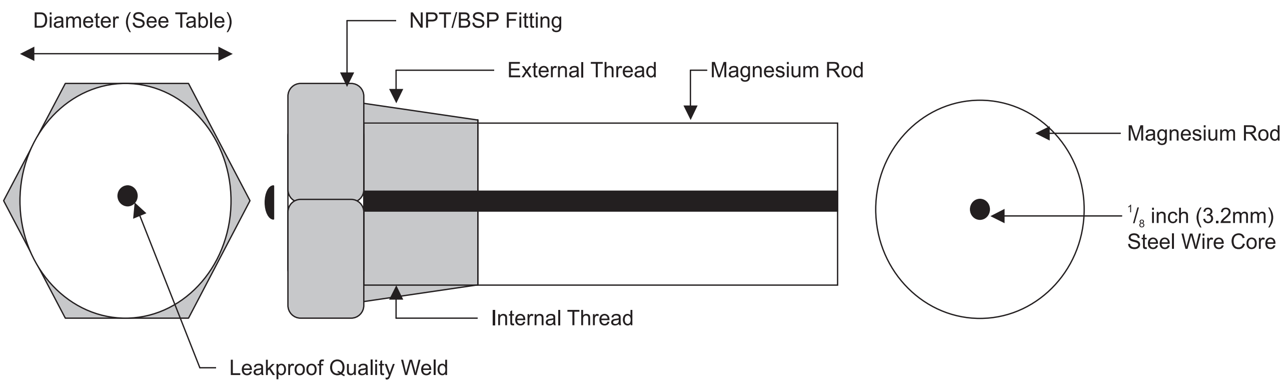
Anode Size: 19mm to 32mm in diameter x variable lengths up to 5m long with a 3,2mm steel wire core. Other anode sizes are available on request.

Electrochemical Capacity	
Potential	-1.5V Cu/$CuSO_4$ Reference Electrode
Capacity	545 Amp hrs/lb 1200 Amp hrs/kg

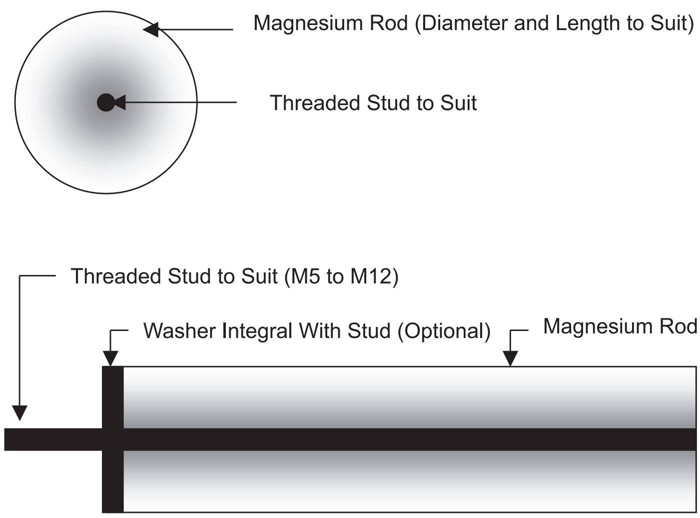
Diameter		Length of Rod
mm	inch	m
19	¾	0 – 5
21.3	13/16	0 – 5
22.8	7/8	0 – 5
25.4	1	0 – 5
26.7	1 1/16	0 – 5
32	1 ¼	0 – 5

Chemical Elements %		
Metal	AZ31	AZ63
Al	2.5 - 3.5	5.3 - 6.7
Mn	0.2 - 1.0	0.15 - 0.30
Zn	0.6 - 1.4	2.5 - 3.5
Si	0.05 max	0.01 max
Cu	0.01 max	0.02 max
Ni	0.001 max	0.003 max
Fe	0.003 max	0.003 max
Other each	0.05 max	0.05 max
Other total	0.3 max	0.3 max
Mg	Balance	Balance

MAGNESIUM ROD ANODES WITH THREADED FITTING

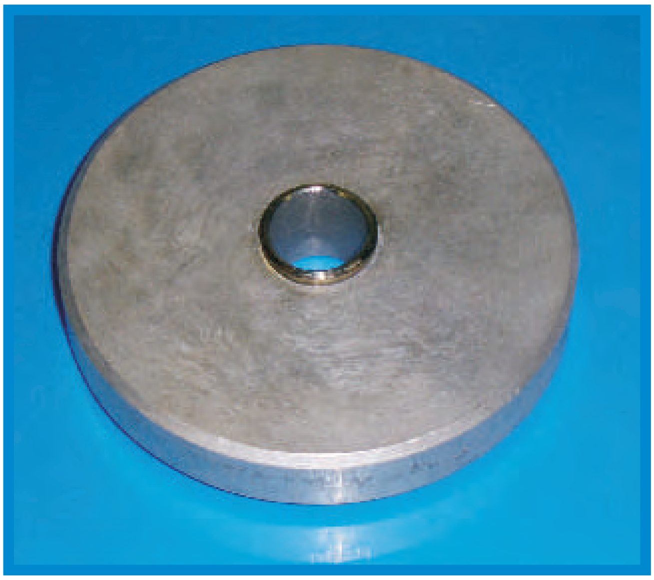


MAGNESIUM ROD ANODES WITH THREADED STUD



2.3.2 Magnesium Disc Anode Alloy AZ63

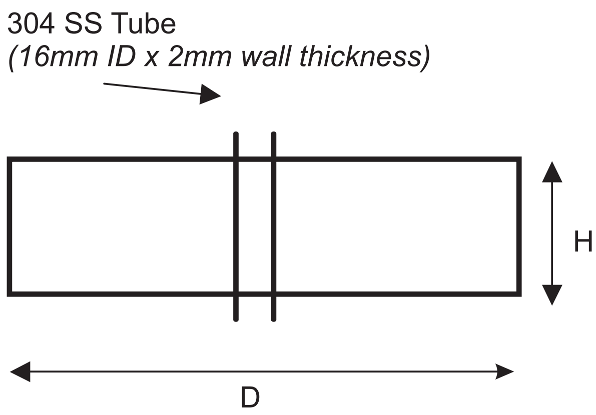
- They are used to protect the internal section of water boxes in heat exchangers.



Anode Size:
100mm, 120mm and 200mm diameter with standard thicknesses from 15mm to 50mm.
All anodes have a 16mm ID SS tube cast in the centre. Other anode sizes are available on request. Individual anode weights vary from 0.2kg to 2.74kg.

How to order: Please quote anode diameter and thickness, or alternatively the anode weight.

D	H (mm)	Wt. (kg)
100	15	0.205
	20	0.27
	30	0.410
	40	0.52
	50	0.68
120	20	0.394
	30	0.590
	40	0.788
	50	0.983
200	50	2.74



2.4 ZINC RIBBON ANODES(with steel wire core)

- Zinc ribbon anodes are utilized to protect underground and submerged pipelines and storage tanks and as AC mitigation electrodes.
- Disa Zinc anodes are manufactured, under strict quality conditions to ASTM B418-88.
- Type II is for soil use and Type I for marine use.
- Type I is only available in Disa 3 and 4 sizes

2.4.1 Zinc Ribbon (Extruded)

It is used to protect coated pipelines, underground storage tanks, and other buried steel structures as well as for AC mitigation.

Ribbon Type	Disa 1 (Small)	Disa 2 (Standard)	Disa 3 (Plus)	Disa 4 (Super)
Cross Section (D1 x D2) mm	8.7 x 11.9	12.7 x 14.3	15.9 x 22.2	25.4 x 31.75
Radius (R1 x R2) mm	1.5 x 3.8	2 x 5	3 x 6.5	5 x 10
Zinc Weight kg/m	0.37	0.89	1.78	3.57
Wire dia. (DW) mm	3.55	3.55	3.55	3.55
Standard Coil Length m	300	150	120	60
Packaging Nominal mm	Wood Reels 900 OD 300 Wide	Wood Reels 900 OD 300 Wide	Wood Reels 800 OD 500 Wide	Wood Reels 800 OD 500 Wide

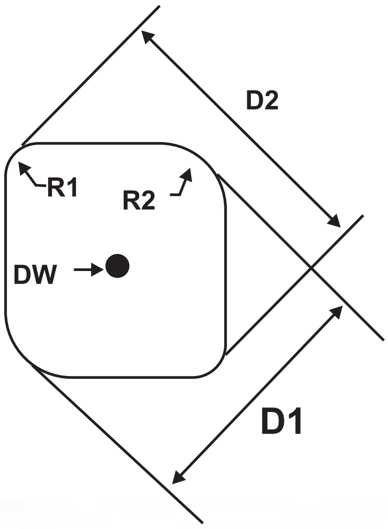
How to order: Please ensure that you quote the type of alloy, the type of ribbon required, size and the length of ribbon per coil.

Zinc Specification

Element % (Max) unless otherwise stated	Al	Cd	Fe	Pb	Cu	Other Total	Zn
ASTM B418 - 88 Type II	0.005	0.003	0.0014	0.003	0.002	---	Balance
Mil - A - 1800IK and ASTM B418 - 88 - Type I	0.1 - 0.5	0.025 - 0.07	0.005	0.006	0.005	---	Balance

TOLERANCE: Cross section, weight and coil length: ± 5%
Wire diameter ±10%
All other measurements are nominal
Other Coil Lengths Available

Electrochemical	
Potential	-1.1V Cu/CuS04 Reference Electrode
Capacity	780 Amp hrs/kg



Recommended procedure for connecting to copper cable is the same as used for the Magnesium Ribbon Anode

3. REFERENCE ELECTRODES

- Reference electrodes (RE) are used to determine if a structure is cathodically protected. This is carried out by measuring the potential (difference in voltage between the reference electrode and the structure).
- The most common RE are the saturated Copper/Copper Sulphate and the Silver/Silver Chloride
- Saturated Copper/Copper Sulphate reference electrodes are available in three configurations.

3.1 PORTABLE Cu/CuSO$_4$ ELECTRODE

- Is a conventional portable electrode, commonly used for the measurement of buried pipe potentials.
- The electrode consists of 150mm long x 25mm dia transparent polycarbonate housing and a porous ceramic bottom plug with a 10mm dia copper rod in a saturated copper sulphate solution. It is supplied with a moisture retention cap. A sleeve impervious to light is available as an optional extra.
- The end terminal can take a banana jack lug or a straight cable.
- The RE is designed such that it can be easily refurbished.

Bottom plugs are available in high and low porosity grades.

VARIOUS CERAMIC BOTTOM PLUGS AVAILABLE
(All are interchangeable with each other)

ROD

SPHERICAL

CONICAL
(Specially designed for CIPS)

3.2 PERMANENT Cu/CuSO$_4$ ELECTRODE

- It is used for permanent buried applications and is supplied with a standard cable of 16mm^2 x 5m PVC/PVC; other cable lengths and sizes are available on request.
- Permanent reference electrodes can be manufactured to customer size on request.
- The electrode consists of a 250mm long x 50mm dia PVC tube containing a CuSO4 gel, copper electrode and ceramic bottom plug.
- It has a minimum life of 20 years.
- The impedance of the bottom plug is set out below
- The electrodes can be supplied in a bag with low resistivity moisture retention backfill.

% Moisture	Impedance (ohms)
5	8184
10	4734
15	1307

Note: % moisture refers to the moisture content inside the reference electrode and in the soil.
The latter had a resistivity of 2250 cm when saturated.

3.3 *IR FREE $Cu/CuSO_4$*

- These electrodes are used for permanent buried application, obtaining “IR” free readings.
- The electrode consists of a 100mm dia x 250mm long PVC housing containing a copper electrode a copper sulphate gel, a ceramic bottom plugs and steel discs.
- The bottom base contains a ceramic plug and three steel discs of 5, 10 and 50mm dia to simulate various defects in the pipe coating.
- The electrode is supplied with a 5m long 4 core cable, which is connected to a special terminal in a test post. The terminal can be set to connect to any of the steel discs.
- The RE has a minimum life of 20 years
- The electrodes can be supplied in bag with a low resistivity moisture retention backfill
- The impedance of the bottom plugs is set out below when tested under the same conditions as described previously.

% Moisture	Impedance (ohms)
5	11350
10	6118
15	1993

3.4 *Portable Ag/AgCl Electrode*

- The electrodes are available in two types, one for marine (Type 1) and one for soil/concrete/fresh water applications (Type 2)
- Type 1 consists of a 1mm silver wire wound around a 10mm dia. PVC rod, all housed in a transparent polycarbonate tube (250mm long x 25mm dia.) and fitted with a bottom ceramic plug. It is supplied with 20m x 6mm^2 of PVC/PVC insulated copper cable directly connected to the silver wire by means of an insulated joint. The electrode is specially treated to form a film of AgCl on the silver wire surface. The electrode is filled with sea water prior to use.
- Type 2 is similar to Type 1, except that it has a saturated AgCl gel and moisture retention cap.

Marine

Soil /Concrete

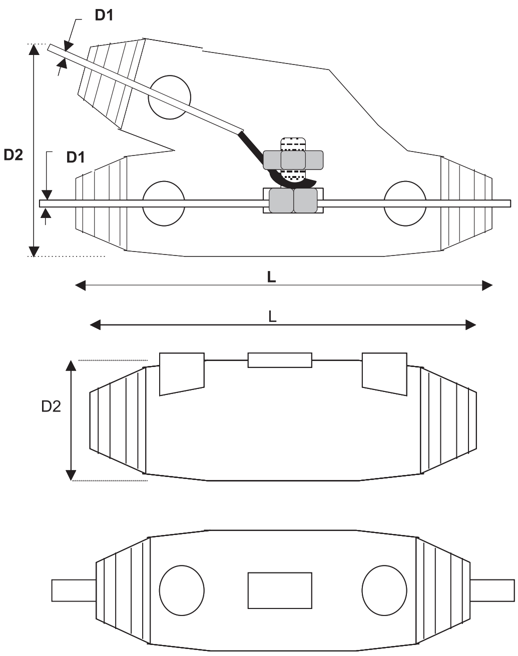
4. CABLE AND CABLE JOINTING MATERIAL

4.1 CABLES

- Disa Anodes supplies double and triple insulated single core copper and aluminium cable for a variety of cathodic protection applications.
- These include header and ring main cables for anode groundbeds, pipeline to rectifier, cross bonding, test posts etc.
- Cables are available in sizes from 4mm^2 to 70mm^2 and insulations such as PVC/PVC, PVC/HMWPE, PVC/XLPE or even a triple coating of PVC/HMWPE/PVDF with any one of the above as insulation or sheathing.
  PVC = Poly Vinyl Chloride
  XLPE = Cross Linked Polyethylene
  HMWPE = High Molecular Weight Polyethylene
  PVDF = Poly Vinylidene Fluoride
  Cables supplied in minimum of 100m lengths

4.2 CABLE JOINTING (SPLICING) KITS

- Two way and three way jointing kits specially designed for Cathodic Protection and specialized, low voltage, applications are available.
- The cable kit contains clear plastic mould, two parts pourable polyurethane resin, cable sealing tapes and mixing instruction sheet.
- Pot life is half hour and setting time is one hour.



THRU AND TEE TYPE KIT

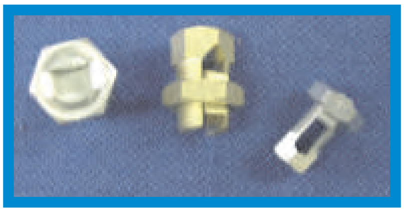
Type	Length (mm)	D2 (mm)	Cable Dia. D1 (mm)		Weight (kg)	Cable Size (mm^2)	
			Min.	Max.		Min.	Max.
THRU	240	47	10	25	1.0	6	120
TEE	183	65	6	20	1.0	4	95

4.3 HEAT SHRINK TUBING

Heat shrink tubing is available for all type of cable sizes for neat cable connections or cable coating repair.

4.4 LINE TAPS (SPLIT BOLTS), "C" CRIMPS AND FERRULES

They are used to join anode cable to the anode bed ring main and also for cable to cable connections. Line Taps are available in tinned brass complete with washer and nut in four sizes.



Line Taps	Cable Size (mm^2)	
	Min.	Max.
Disa LT1	6	16
Disa LT2	25	35
Disa LT3	50	70
Disa LT4	95	-

5. INSULATING FLANGES AND SPARK GAPS

5.1 INSULATING FLANGES & INSULATING JOINTS

- Disa Anodes manufactures industry standard Insulating Flanges (IF) and distributes Insulating Joints (IJ).
- Insulating Flanges and Insulating Joints are used to electrically isolate pipelines under cathodic protection from other metallic structures, such as earthing systems, motors, pump stations or unprotected pipelines.
- A complete insulating flange set comprises an insulating gasket, bolt sleeve and washers; steel washers and stud bolts and spark gap for protection of insulating material against lightning.
- Insulating Flange sets are available in all diameters and to any specification e.g. SABS, BS, API, etc.
- Due to the great variety of IF sets, it is not possible to keep stock of all sizes, and therefore orders should be place timeously.
- When ordering please specify the following:
  ✓ Flange Standard, size and pressure rating.
  ✓ Whether machined steel washers and stud bolts are required. The size of the latter must be specified.
  ✓ Whether a spark gap with brackets is required.
- Insulating Joints (IJ) are of monolithic construction i.e. they come as one piece and require to be welded at each end into the pipeline system. Because of their construction, IJ are considered superior to, but more expensive than, insulating flanges.

INSULATING JOINT

INSULATING FLANGE

The insulating gasket consists of a 3mm thick fabric reinforced phenolic resin with 1mm thick neoprene rubber layer on each side.

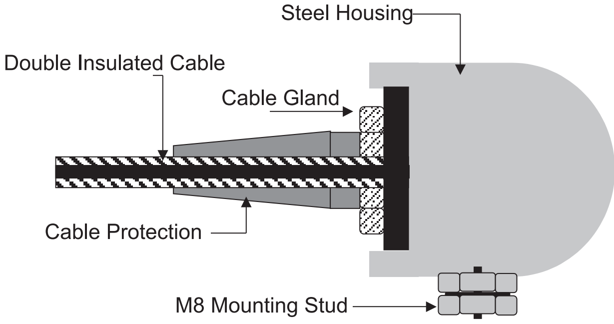
The insulating sleeves are made of a 1mm thick wall glass reinforced epoxy resin.

Please consult our sales department for applications where the temperature exceeds 75°C or where liquid organic solvents are used.

5.2 SPARK GAPS

- The spark gaps are manufactured from sturdy epoxy coated steel.
- The construction is explosion proof using long lasting copper/tungsten electrodes.
- They are generally used for the protection of insulating flange and joints against lightning and voltage transients as well equipotentialization.
- The spark gaps are supplied with two galvanized steel brackets, one of which is fixed to each flange and to which the spark gap is connected.
- The spark gaps are supplied with 5m of flexible 25mm PVCPVC insulated copper cable and two galvanized steel brackets for mounting to the flanges

HOW TO ORDER: Please always quote the bolt size and the application to be used.



Technical Data	
Type	Explosion Proof Copper Tungsten Electrodes
Discharge Current	≤ 100kA
Lightning Impulse Current	≤ 120kA
AC Spark over voltage (50Hz)	≤ 750V
Standard Lightning impulse spark over voltage (1.2/50)	≤ 2.2kV
Protection class/application	• Lightning protection • Equipotentialization • Installation at insulating flange sets • Couplings of cathodically protected pipe sections
Housing	Die Pressed, mild steel, zinc plated and epoxy coated moisture proof housing
Connections	25mm^2 PVC/PVC double insulated 6m long cable and M8 brass screw/nut
Mounting	Hot-dip galvanised mild steel brackets to suit flange
Dimensions	Diameter 65mm Length 55mm

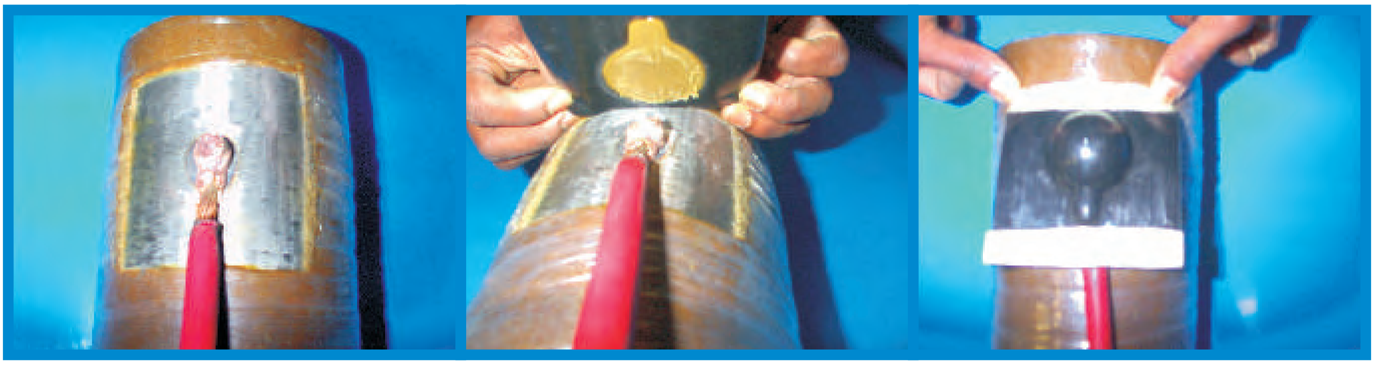
6 PIPE COATING REPAIR MATERIALS

6.1 PETROLATUM TAPES, MASTIC AND PASTE

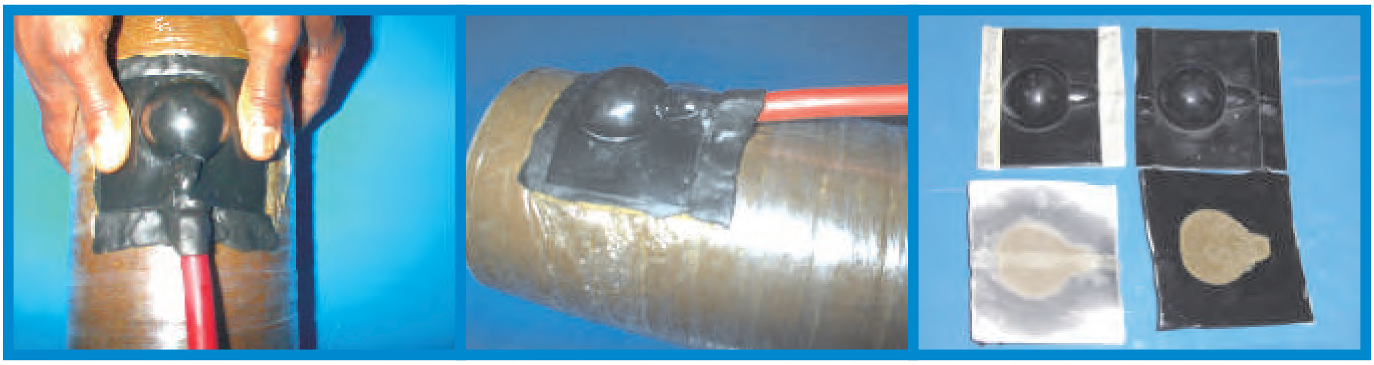
- Disa Anodes manufactures and distributes a range of coating repair materials based on petrolatum tapes and Denso products
- These include primer, paste and mastic.

6.2 DISA PROTECTION CAP

- The Disa Protection Cap is a simple and easy to apply kit which is used for the repair of pipeline coatings after a cable connection by means of exothermic welding or pin brazing has been made.



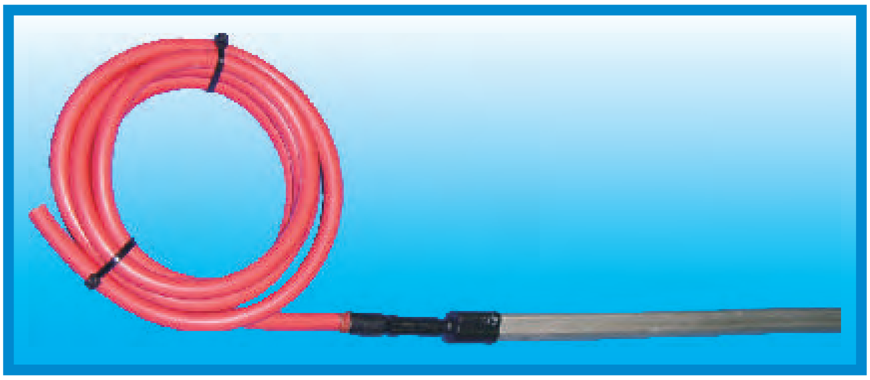
- The kit consists of a sheet of rubberised bitumen with a recess containing a specially formulated mastic compound.
- The rubberised bitumen is sticky and will adhere readily to any pipe coating so as to provide a moisture proof seal.
- The recess is large enough to accommodate an exothermic weld or a pin braze connection.
- The size of the rubberised sheet has been dimensioned to fit over the base steel area.
- The steel surface must be free of dirt and grease prior to installation of the kit.
- The kits are supplied in boxes of 10 with simple, clear instructions for their installation.



7. AC MITIGATION AND EARTHING ELECTRODES

7.1 ZINC EARTH RODS (Extruded)

Zinc rod anodes are also available in the following diameters and lengths, with a steel 3,2mm dia. wire core. Either as a 1500mm long x 15mm dia. Rod with a 3,2 mm steel wire core and 3m x 6mm^2 PVC/PVC insulated copper cable or in the Disa 3 ribbon shape and in coil form to any length.



7.2 GROUNDING AND POLARISATION CELLS

GENERAL DESCRIPTION
Both Grounding and Polarisation cells are technically classified as voltage dependant electrolytic resistors or electrolytic varistors.
Grounding Cells (GC) are buried and normally require no maintenance, whereas Polarisation Cells (PC) are installed above ground and may require topping up with water from time to time.

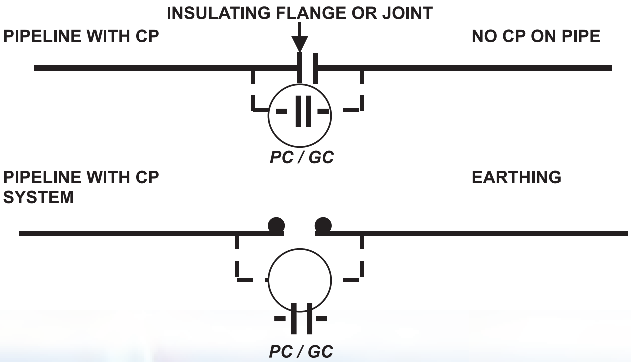
USES AND APPLICATIONS
Both devices consist of two plates or electrodes arranged either in single or multiple pairs, to form series or parallel arrangement, to suit a particular application. GC and PC are used for the following situations:

1. Protection of insulating flanges and insulating joints against dielectric breakdown of the insulating materials caused by lightning or other voltage transients.
   The GC or PC starts conducting an electric current at low voltages thereby acting as a short and preventing the voltage from rising to destructive levels.

2. In situations where it is necessary, for safety reasons, to electrically connect two separate systems say a pipeline system and an electrical earthing system, but which should be electrically separated from a Cathodic Protection point of view.
   The safety requirements are met since AC and high to medium voltage DC, are easily conducted by the GC or PC but which block low voltage Cathodic protection DC.

3. As a surge or voltage arrestor for Transformer Rectifiers for protection against lightning or other voltage transients.

   The above examples are illustrated below:



7.2.1 GROUNDING CELLS (GC)

Two types of GC are available.
The one type consists of two zinc electrodes (Type Zn) and the other consists of Titanium electrodes (Type Ti). The following technical characteristics apply:

TYPE	OVERALL CELL DIMESIONS DIA X LENGTH (mm)	DC CHARACTERISTIC	AC CHARACTERISTIC	CELL RESISTANCE Ω	CELL CURRENT RATING Amp/sec
Zinc	120 x 600	Blocks up to 1,5V	Passes AC at all voltages	0,005	5000
Titanium	120 x 600	Blocks all DC voltage up to 8-12V. Passes current at higher voltage.	Passes AC at all voltages	0,005	5000

Zinc grounding cells have the disadvantage that the zinc electrodes can suffer galvanic corrosion by virtue of being connected to more noble metals such as steel or copper. This applies especially to the electrode connected to the unprotected Cathodic Protection System. This is complicated by the fact that being buried, failure of the cell may not be evident and testing is not easy.

The cells are supplied with 5m of 35mm^2 PVC/PVC insulated copper cable per electrode.

7.2.2 POLARISATION CELLS (PC)

These perform a similar function to GC, but are located above ground. They have the advantage that the electrolyte can be more carefully designed and controlled, can be readily checked and that the output voltage and current parameters can be better manipulated. The cells may be grouped in series to increase the blocking voltage or in parallel to increase the current capacity.
The one disadvantage is that it may require some maintenance in the form of topping up. Two types of PC are available. The one consists of two electrodes (each electrode consisting of a number of parallel plates) of 304 SS in a concentrated Sodium Hydroxide solution.

The second type consists of titanium electrodes in a Sodium Sulphate solution. One unit contains four cells which may be connected in series to form blocking voltages of 60, 120, 180 and 240 volts, or in parallel.

The following technical characteristics apply:

TYPE	DC CHARACTERISTIC	AC CHARACTERISTIC	CELL RESISTANCE Ω	MAX CURRENT RATING Amp sec
304 SS	Blocks up to 2V	Passes AC at all voltages	0,001	20 000
Titanium	Blocks at intervals of 60, 120, 180 and 240 Volts.	Passes AC at all voltages	0,001	10 000

7.3 COPPER PLATED STEEL EARTH RODS

These are available in 16mm diameter and lengths of 1,2m, 1,5m, 1,8m and 2,4m with a 250 micron copper coating. The rods can be threaded at the ends so as to connect one to the other by means of a bronze coupling.

Connection to the copper cable is carried out by means of bronze coupling or exothermic welding. The rods may be driven into the ground or inserted into a pre-drilled hole.

8. EXOTHERMICS, GRAPHITE MOULDS AND ACCESORIES

- Disa markets the well-known Exoweld range of exothermic equipment materials.
- Weld metal is supplied in standard sizes No. 15, 25, 32 and 45. Larger sizes are available on request.
- Graphite moulds are available for all applications; these include single and through welds on horizontal pipelines using flat based moulds for larger diameter pipelines as well as curved based moulds for small diameter pipelines.
- Other items in the range include flint gun igniters, sealing putty, handle clamps, etc.
- When a low welding temperature is desired, so as not to damage the inner lining of a pipe, a special prepared pad is available. The exothermic welding is carried out on this pad.

- It is used to weld cable or anode cable to pipeline. Generally used for continuity bonding along Viking Johnson or flanged pipelines.
- Please always quote cable size and pipeline diameter for the correct supply of welds and moulds.
- Also quote the type of cable bonding, chamber, continuity, flat or vertical.

GLOSSARY OF CATHODIC PROTECTION TERMS

Anode
An electronic conductor (metal or graphite) at whose surface a direct current leaves to enter the electrolyte. It is connected to the positive terminal of a D.C. power source.

Anode (Impressed Current)
Anodes used for impressed current cathodic protection consist of high silicon iron, magnetite, graphite, platinum-titanium and mixed metal oxide (MMO) coated-titanium.

Anode (Sacrificial)
Consist of magnesium or zinc or aluminium.

Anode Capacity
Is a measure of the life of an anode and is expressed in amp hours or amp years. For example, the capacity of zinc is 780 amp hours/kg so that a block of zinc weighing 6kg and passing 0,1 A will have a life of

$$\frac{6 \times 780}{0{,}1} = 46800 \text{ hours} = 5{,}3 \text{ years}$$

Anode Groundbed
Consists of a number of individual impressed current anodes buried in a trench about 2m deep and surrounded with coke. A typical groundbed consists of 30 silicon iron anodes and is 120m long.

Anode Groundbed Resistance
The electrical resistance between the anode and earth.

AC Mitigation
A technique for decreasing or eliminating AC voltages on pipelines or structures.

Bonding (Chamber)
Continuity bonding inside a valve chamber.

Bonding (Continuity)
Providing electrical continuity across mechanically coupled lengths of pipe e.g. Viking Johnson couplings, flanges, spigot and socket, threaded couplings.

Cathode
An electronic conductor (metal or graphite) at whose surface a direct current enters from the electrolyte. It is connected to the negative terminal of a D.C. power source.

Cathodic Disbonding
The loss of adhesion of a coating from the metal surface during cathodic protection at very negative potentials.

Cathodic Protection
An electrochemical method of corrosion protection. It consists in passing a direct current from the corroding medium on to the structure requiring protection.

Cathodic Protection (Impressed Current) ICCP
A technique in which the structure to be protected is connected to the negative terminal (the cathode) of a D.C. power source such as transformer rectifier. The positive terminal is connected to the anode.

Cathodic Protection (Sacrificial Anode)
A technique in which the structure to be protected (the cathode) is connected to a more electro negative metal such as magnesium, zinc or aluminium (the anode). The system does not require an external source of power as it generates its own electrical current.

CIPS
Acronym for Close Interval Potential Measurement, which is a technique for the measurement and recording of the pipe potential every 1-2 m along the pipeline route. It is used for locating underprotected areas and coating defects.

Coke
An electronically conducting form of carbon. Two types are available; petroleum coke and coal coke.

Copper Sulphate Reference Electrode (CSE)
Consists of a copper rod in a saturated copper sulphate solution. It is universally used for measuring the potential of buried pipelines.

Current Density
The current density required to achieve protection at a cathode. It varies from $0{,}01mA/m^2$ for a well coated surface in the ground to $1\ 00mA/m^2$ for bare steel in sea water.

Current Drainage Survey
Practical site tests, carried out to determine the total current required to protect a particular structure. It consists of injecting current into the pipeline or structure until protection is achieved. It is in essence a temporary cathodic protection installation.

Direct Current Voltage Gradient (DCVG)
A technique for locating coating defects along a pipeline.

Electro Osmosis
The phenomenon whereby the water in the ground diffuses away from the anode under the influence of a direct current, which results in a increase of the anode to ground resistance.

Exothermic Welding
A method of welding a copper cable to a steel surface. It consists of igniting a mixture of copper oxide and aluminium powder. The reaction produces intense heat resulting in molten copper. The method is quick and inexpensive.

Forced Drainage Unit (FDU)
A transformer rectifier unit which uses an electrified railway line as the anode.

Galvanic Corrosion
Corrosion of one metal by another. Typical examples are steel connected to copper or stainless steel. The former is anodic and corrodes while the latter is cathodic and protected.

Grounding Cell
A device which is buried in the ground next to an insulating joint or flange, in order to protect the latter. It limits the voltage across the IF or IJ to levels below the dielectric strength of the insulating material.

Half Cell
A reference electrode.

Insulating Flange
Two steel flanges mechanically coupled but electrically insulated by means of appropriate gaskets, washers and bolt sleeves.

Insulating Joints
A single (monolithic) spigot and socket arrangement whereby the two pipe halves are insulated from each other. It is supplied as one whole.

GLOSSARY OF CATHODIC PROTECTION TERMS (Continued)

IR Drop
The error in measuring the pipe potential due to current flow in the electrolyte (ground).

IR Free Reference Electrode
This electrode is also installed permanently, but in addition, it contains steel discs, or coupons, which enables one to take "IR Free" or "error free" measurements.

Natural Drainage Unit (NDU)
A device which permits stray currents to flow from pipe to rail via a metallic conductor, rather than through the ground. It requires no external source of power.

Permanent Reference Electrode
An electrode which is permanently installed in close vicinity to the structure; this may be in soil, water or concrete.

Pipeline Integrity Management
A philosophy which considers all the factors (holistic) that contribute to the successful maintenance and operation of a pipeline. Cathodic Protection is one of these factors.

Polarisation
The change in potential upon flow of current to or from a structure.

Potential
The difference in voltage between a structure and a reference electrode.

Potential (Natural)
The potential of a naturally corroding piece of metal. For steel in soils and waters it is about -0,5V (CSE).

Potential (Negative)
This indicates that a structure is cathodic and therefore wholly or partially protected.

Potential (Off)
The potential measured within 1 second of the current being switched "off". The potential is said to be IR and error free.

Potential (On)
The potential measurement with current flowing or, "on". This includes an IR drop.

Potential (Positive)
This indicates that a structure is anodic and therefore undergoing accelerated corrosion.

Potential (Protective)
The potential required to achieve cathodic protection. This is normally -0,85V with respect to a copper sulphate reference electrode, or -0,95V when anaerobic sulphate reducing bacteria are present.

Reference Electrode (RE)
A device which permits the measurement of the potential of structures. The potential of the reference electrode proper does not vary regardless of the electrolyte it is immersed in (within reason) nor of the flow of current, and hence acts as a "reference". Common RE are copper/copper sulphate for ground applications and silver/silver chloride for marine conditions.

Remote Monitoring
A technique for the measurement and recording of cathodic protection data (generally pipe or tank potential) by means of a telephonic line (landline or cellular), which obviates the need of sending personnel to site to do a physical measurement.

Soil Resistivity
The specific electrical resistance of the soil and is a measure of the soil corrosivity. The lower the resistivity the higher the corrosivity.

Stray Currents
Electric currents flowing in the ground which follow a path other than that intended. The major sources are traction stray currents which are fluctuating, or from other cathodic protection systems, which are steady. Stray currents cause accelerated corrosion to steel pipelines.

Sulphate Reducing Bacteria (SRB)
Microorganisms which cause corrosion to steel in heavy, waterlogged soils which have minimal oxygen content (anaerobic). The phenomenon also occurs in many waters. Generally referred as Microbiologically Induced Corrosion (MIC).

Test Point
A measuring point located in a valve chamber. This also permits the ready measurement of the pipe potential.

Test Post
A free standing steel or concrete structure, standing about 1m above ground and 0,3m below, having a cable connected to a pipe. This permits the ready measurement of the pipe potential.

Transformer Rectifier Unit (TRU)
An electrical device fed by 220V or 380V AC and producing low voltage direct current. In essence it consists of a step down transformer and a rectifier bridge.

FUNDAMENTALS OF CORROSION AND CATHODIC PROTECTION

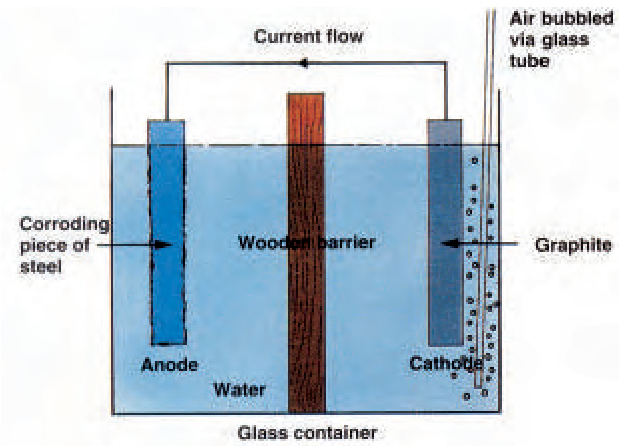
The corrosion of steel (iron) in soils and waters is represented chemically as follows:

$2Fe + 2H_2O + O_2 \rightarrow 2Fe(OH)_2$
Iron + water + oxygen → Ferrous Hydroxide (rust)

The above reaction is informative but does not provide any information regarding (1) the speed of corrosion, (2) why electric currents can accelerate or prevent corrosion and (3) the actual mechanism of corrosion.

It is well established that aqueous corrosion occurs by means of an electrochemical mechanism. This is explained below:

Consider a piece of steel and one of graphite in a container of water. The two are separated by a slab of wood or ceramic which allows the ions in the water to pass freely but prevents bulk mixing of the two sides of the water. Allow air (oxygen) to be bubbled into the compartment with the graphite.



It is found that there is about 0,5V difference between the graphite and water, and about 0,6V between the steel and water, resulting in a net voltage difference of about 1,1 V. If the two are joined by a copper cable, an electric current will flow. The graphite will be the cathode and steel the anode. The reactions producing the electric current are represented as follows:

Anode
$2Fe \rightarrow 2Fe^{2+} + 4e^-$.
solid iron → iron ions in solution + electrons

This reaction represents corrosion since solid iron is converted into soluble ions which enter the water. The electrons which are produced remain on the metal surface and travel to the cathode.

$O_2 + 2H_2O + 4e^- \rightarrow 4OH^-$
dissolved oxygen + water + electrons → hydroxyl ions

This reaction consumes the electrons which travel to it from the anode.

Adding the two reactions, we obtain:

$2Fe + O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4OH^- \rightarrow 2Fe(OH)_2$
Ferrous hydroxide or rust

The separation of the container into oxygen rich and oxygen poor areas has been done to simplify the technical discussion, although such a situation does arise in a number of practical instances.

Consider for example a pipeline travelling through a low lying marsh area. The pipe in the marsh will be lacking in oxygen while that in the higher ground will be reasonably aerated so that the former will be anodic and undergo corrosion and the latter cathodic and be protected. Such a situation is very common in South Africa.

The above situation is characterised by the fact that the cathodic and anodic areas are well demarcated and separate from each other.

In many instances such as the corrosion of steel immersed in water or in acids, the corroding surface consists of numerous small anodes and cathodes lying next to each other. These constantly shift in time and place, and the net result is uniform corrosion.

The rate of corrosion is directly related to the magnitude of the electric current; one Amp flowing for one year corrodes 9 Kg of steel. The smaller the area over which this occurs the greater the depth of penetration.

The voltage difference between the electrolyte and the anode, or cathode is termed the potential and develops because of the separation of electric charges.

With respect to the anode reaction, it may be made to proceed from right to left, by adding electrons (instead of withdrawing them), such as by connecting to the negative terminal of a battery or DC power source such as a battery charger. The reaction then becomes $2Fe^{2+} + 4e^- \rightarrow 2Fe$; any iron ions which may be present in solution will be deposited, such as in electroplating. This is the essence of cathodic protection; namely altering the potential of a metal surface such that dissolution (corrosion) cannot occur, but rather its opposite (metal deposition) is the only possible reaction. The fact that metal deposition does not occur because such ions are not present in soils or waters is not important.

Cathode

FUNDAMENTALS OF CORROSION AND CATHODIC PROTECTION

On a practical level cathodic protection is achieved by connecting the structure to be protected to the negative terminal of a DC power source (and hence becoming the cathode) and connecting the positive terminal to another piece of metal (which becomes the anode), such that an electric current passes between the two. Provided that the potential at the cathode is more negative than -0,85V, corrosion cannot occur and protection is achieved.

A direct electric current is always associated with cathodic protection. The current density required to achieve protection varies enormously from buried soils to flowing oxygenated waters. Coated steel greatly decreases the current density requirements since the current can only flow at defects in the coating. Typical current density values needed to achieve protection are set out below:

• very well coated buried steel pipe	0,01 mA/m^2
• moderately well coated buried steel pipe	0,1m A/m^2
• bare buried steel in corrosive soil	30mA/m^2
• bare steel in sea water	100mA/m^2
• bare steel in flowing, aerated water	250mA/m^2

In environments (electrolytes) with little or no oxygen, the main cathodic reaction is hydrogen evolution;

$2H^+ + 2e^- \rightarrow H_2$

Hydrogen ions + electrons → Hydrogen gas

We have the situation therefore that at a cathode due to the consumption of H^+ ions, the hydroxil ions OH^- increase, with consequent rise in alkalinity or pH. This is beneficial since steel is protected in high pH environments (e.g. concrete), and is indicated by the presence of white deposits of Calcium and Magnesium hydroxides and carbonates.

USES AND LIMITATIONS OF CATHODIC PROTECTION

Cathodic protection is a proven, successful and widely used method of corrosion prevention to a great variety of steel structures. It is well established that corrosion is an electrochemical phenomenon, whereby a corroding surface consists of anodes and cathodes, with corrosion occurring at the former and protection at the latter. By the application of a suitable voltage, the whole surface is rendered cathodic and hence fully protected. This is only a very brief introduction and a detailed explanation is given in the previous page.

Cathodic protection is widely used for the external protection of buried pipelines, flat bottom tanks, buried tanks, offshore gas and oil platforms, inside of water tanks, pipelines and condensers, settling tank rake arms, steel in concrete structures, ships and many other applications.

Cathodic protection lends itself to protection in all soils and natural waters, including brackish and sea water. It is also applied in a variety of chemicals and solutions, but enquiries should be first made for these applications.

In South Africa it is estimated that over 20 000km of buried pipelines are under cathodic protection. This includes the 600km Durban - Johannesburg oil lines, the 860km Pande - Secunda gas line, the 300km Vaal Gamagara water line for the Department of Water Affairs and Forestry, as well as numerous pipelines and tanks belonging to the Oil and Gas Companies, Water Boards and Municipalities. All the buried steel pipework at the Sasol plants is cathodically protected as are also the flat bottom tanks resting on the ground.

Other examples include the common household hot water geyser (which is protected by a sacrificial magnesium anode), the rake arms of the 130m dia thickeners at Ergo, the offshore Mossgas gas platform, the inside of the Eskom Lethabo Power Station Cooling Water Ducts.

Cathodic protection is often used on coated surfaces, the combination (coating + cathodic protection) generally being more economical than either alone. In such instances, the cathodic protection current flows to defects in the coating.

There are two methods of applying cathodic protection. The one is by sacrificial (or galvanic) anodes, and the other one is called impressed current cathodic protection. These are explained in the following pages.

As a rough estimate the cost of cathodic protection is about 1 % of that of the structure to be protected.

Cathodic Protection is successful...

- For the protection of bare and coated structures
- In all types of soils including acid soils and those containing Sulphate Reducing Bacteria.
- When stray currents are present.
- For the protection of Iron, Cast Iron, Steel, Galvanised Steel, Copper, Stainless Steel and Lead.
- For the protection of the outside and inside surfaces, whether bare, coated or encased in concrete.
- From above the freezing point to the boiling point of water. Under high pressure, the latter may exceed 100°C.
- In all waters including brackish and sea water.
- In many "abnormal" waters and solutions e.g. mine waters, chemically contaminated water, industrial effluent, etc, as well as in many chemical solutions.
- For the protection of steel in concrete.

Cathodic Protection is not generally used ...

- For protection against atmospheric corrosion or corrosion due to condensation.
- In strong acid solutions.
- For protection against steam or fumes.
- In situations with a complicated geometry such as a bundle of condenser tubes, or in cramped environments such as the inside of a small diameter pipeline.
- For the protection of Aluminium.

SACRIFICIAL ANODE CATHODIC PROTECTION

When a metal is placed in an electrolyte (water or ground) a voltage difference arises between the metal and the electrolyte. This is termed the "potential" and every metal has its own specific value. The values for some of them are shown below:

Gold	+0,6V
Copper	-0,2V
Iron	-0,6V
Zinc, Aluminium	-1,1V
Magnesium	-1,6V

The above forms part of what is called the galvanic series. When any two metals in the series are connected, the metal with the more negative potential becomes the anode and is corroded while the other metal becomes the cathode and is protected. Thus iron is used as an anode to protect copper, and zinc, magnesium or aluminium are used as anodes to protect iron (steel). The anodes in such instances are referred to as sacrificial.

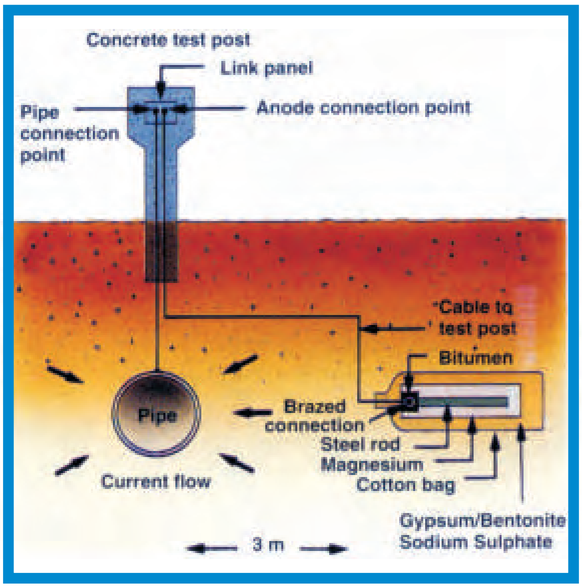
A typical sacrificial anode installation for buried steel pipelines consists of 2 magnesium anodes (7,7 Kg each) buried 3m from the pipe, and every 100m along the pipeline route. The anodes are connected to the pipe via a copper cable.

Advantages

- Generates its own electricity (does not require external power).
- Requires virtually no maintenance and is very reliable.
- Easy to install.
- Impossible to accidentally reverse polarity.
- Typical life of 15 - 20 years depending on design

Disadvantages

- Installations are expensive.
- Performance (current output) depends on soil resistivity.
- Driving voltage is generally insufficient to overcome voltages from stray currents.



IMPRESSED CURRENT CATHODIC PROTECTION (ICCP)

This technique utilises 220V or 380V AC to feed a step down transformer and rectifier bridge to produce, typically, 50V 50A DC. The negative terminal is connected to the structure to be protected (say a pipeline) and the positive terminal to the anode. A typical installation is shown below.

The anode is referred to as the groundbed when buried and actually consists of a series of individual anodes buried about 2m deep and separated an equal distance end to end. The anodes require to be made of special non corrodible materials such as high Silicon Iron, Graphite or MMO-Titanium; steel is seldom used as an anode since it corrodes at a high rate. Anode groundbeds generally vary in length from 50 to 300m (depending on the electrical resistivity of the soil) and lie 150 to 200m from the pipe.

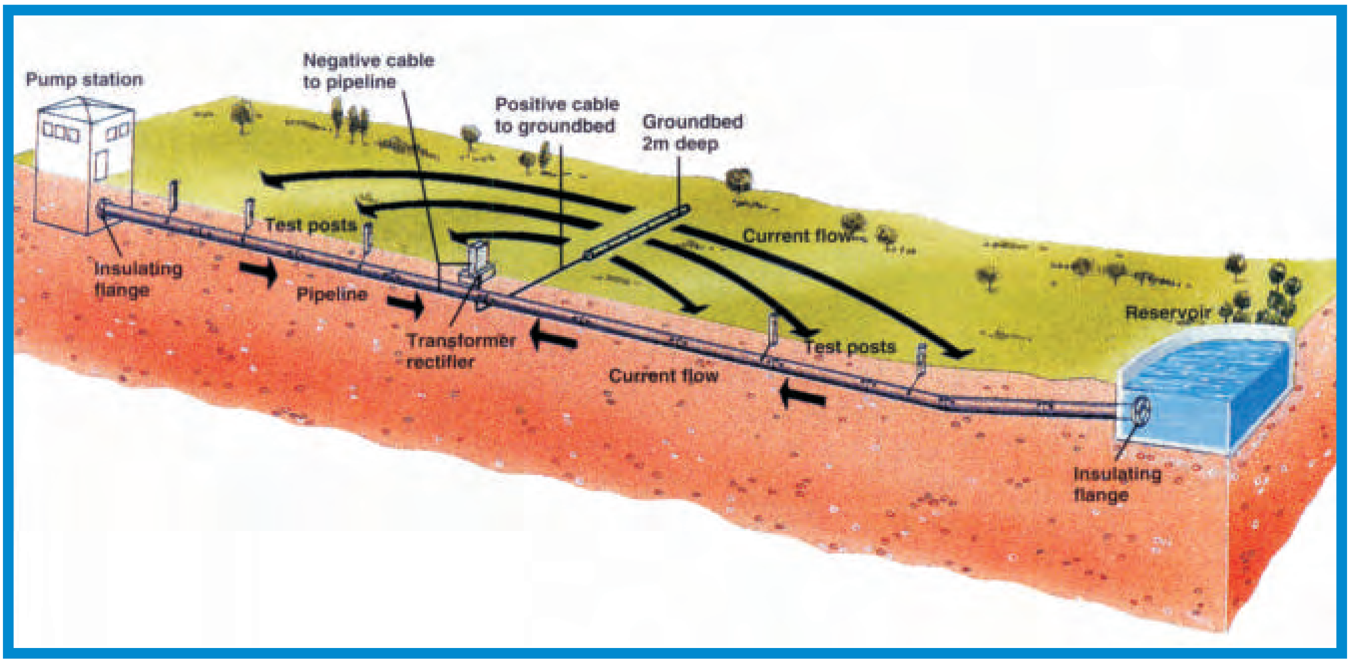
Test Posts are required every 500m or 1 km to monitor the level of protection.

Advantages

- One installation can protect 10- 15km of pipe
- Can counter stray currents.
- Is effective for all types of soils.
- Typical life of 20 - 25 years.
- Effective for bare and coated structures.

Disadvantages

- Requires external source of power.
- Care must be taken to ensure correct polarity, otherwise accelerated corrosion will occur.
- Requires regular maintenance of the rectifier.
- Can cause stray current corrosion to other buried pipelines in close proximity.



Essential features

The essential features of an ICCP system are the following:

- Transformer Rectifier to supply direct current.
- A series of anodes (anode groundbed) buried in the ground at one location to permit current to flow to the cathode.
- Insulating flanges to isolate the pipeline from other metallic structures not requiring protection.
- Pipeline must be electrically continuous.
- Pipeline to have Test Points to permit the monitoring of the CP System.

CATHODIC PROTECTION SURVEYS FOR BURIED PIPELINES

The question often arises - should cathodic protection be installed? If so, what form should it take and what will it cost?

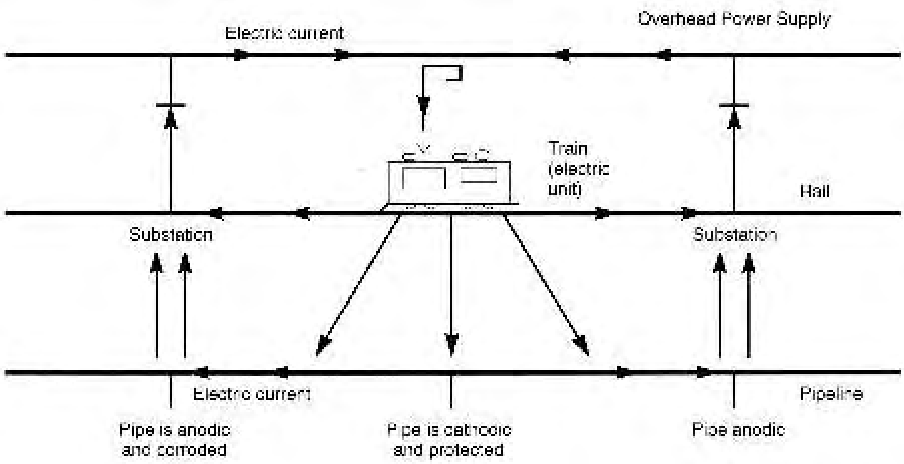
To answer the above questions, it is frequently necessary to carry out field tests or surveys. Seldom can cathodic protection systems be designed "theoretically" purely on the basis of certain data pertaining to the system.
Field surveys consist of firstly determining the nature of the corrosive forces, and then whether these warrant cathodic protection and secondly to assist in designing a cathodic protection system.

Determining the Corrosivity of the Environment (or the need for cathodic protection)

The subject is vast and in this limited space, only the major factors pertaining to buried pipelines will be discussed.

1. Soil Corrosivity Survey
The intrinsic corrosivity of a soil is normally measured "in situ" every 50 or 100m along the pipeline route. This is done by measuring the specific electrical resistance or resistivity of the soil - the lower the resistivity the higher the corrosivity. This is what one would intuitively expect since factors which cause low resistivity such as the presence of dissolved salts and moisture are also those which promote corrosion. It has been shown from experience that for soils of below 50 ohm m, cathodic protection is essential to prevent corrosion. The resistivity is normally measured by the Wenner Four Electrode Method. This consists of driving four steel rods into the ground, equidistantly apart at a separation equal to the pipe invert depth. Current is injected into the outer two rods and the voltage drop between the inner two is measured by means of a null balance meter. The resistivity is then calculated by means of an appropriate formula. Care and experience is required in the interpretation of the resistivity data, since the resistivity obtained is an average, and variations will occur due to seasonal moisture fluctuations, presence of boulders, variations in soil type etc.

In some instances the corrosivity survey is backed up with a chemical analysis of the soil; this includes pH, sulphate, chloride, total acidity, etc.



2. Stray Current Survey

South Africa has a very extensive D.C. traction system. Because the rails are not perfectly insulated from earth, part of the current leaves the rail and returns to the substation via the ground.

Any steel pipelines in the vicinity of electrified railway lines will pick up these stray currents at one point and deliver it at another. This is shown schematically above.

Where the current enters the pipe, the latter becomes "cathodic" and is partially or wholly protected; where it leaves the pipe to return to the rail, intense corrosion occurs (the pipe is "anodic"). The situation is further complicated by the fact that due to a practice known as regenerative braking, the situation described below is reversed. Traction stray currents are therefore highly fluctuating and are also greatly dependent on the frequency, and load, of the traffic.

It is difficult to measure the stray currents flowing in a pipe, and it is more common to measure the pipe potential; positive potentials indicate anodic corrosion conditions and negative potentials cathodic or a protective situation. It should be noted that stray currents can cause corrosion even in high resistivity "non corrosive" soils, although their effect is much more destructive in low resistivity corrosive soils. The loss of metal is 9kg for 1 Amp flowing for one year in the case of steel. If this is spread over a "large" area, the depth of penetration is often tolerable, but if the current is concentrated on defects or pinholes in the coating, the current density is very high and intense corrosion can occur.

CATHODIC PROTECTION SURVEYS FOR BURIED PIPELINES

Another source of stray currents are adjacent cathodic protection systems.

These may be steady or steady/fluctuating depending on whether the offending pipeline is itself subject to stray currents.

A stray current survey consists in recording the potential for several hours at a number of locations along the pipeline route. This identifies the extent of stray current activity and which parts are protected or corroding.

Recordings of electrified rail potential is also carried out. Since stray currents are large - in some instances several hundred Amps - it has become common to use Impressed Current Cathodic Protection using the rail as the anode. Such installations are known as Forced Drainage Units.

3. Bacterial Corrosion
Corrosion due to bacteria, commonly known as Sulphate Reducing Bacteria (SRB) or Microbiological Induced Corrosion (MIC), is becoming more and more frequent. This is due to our waters becoming increasingly contaminated with salts, especially sulphates, which act as nutrient for the micro organism. SRB corrosion occurs in anaerobic (heavy clay, waterlogged) soils as well as in many "industrial" waters. Special Chemical "Kits" are available for detecting the presence of SRB; it is also common to send soil samples to specialized laboratories.
Cathodic protection is fully effective against SRB, provided the potential is raised to -0,95V.

4. Galvanic Corrosion
Just as base metals such as magnesium, zinc and aluminium provide protection to steel, but are simultaneously corroded, so is steel when connected to a more noble metal such as copper. Such galvanic action occurs frequently especially in petrochemical plants where the steel piping is anodic when connected to the copper earthing (which is the cathode). This can be partially dangerous when a large cathode is connected to a small anode, as for example when the latter is represented by small pinholes at the coating of a pipe.

Tests for galvanic corrosion involve the measurement of the potential. Values less negative than -0,5V (for steel) may indicate galvanic action, but this conclusion must be backed up with other data.
The solution to galvanic corrosion is either to separate the two metallic systems, or cathodically protect both of them.

CATHODIC PROTECTION DESIGN

Assuming that it has been established that a structure is being corroded and that cathodic protection is necessary, the next step is to design a cathodic protection system. The following surveys are carried out in this regard.

5. Current Drainage Survey
This is in essence a temporary cathodic protection system. It consists of injecting a known current into the system (pipeline) and observing the change in potential until protection is achieved.

For a water vessel a single test is sufficient, but for a long pipeline more than one test may be necessary and the pipe potential will be measured at many points (before, and after, the injection of current). If fluctuating stray currents are present it will be necessary to record the potential rather than rely on spot measurements. A current drainage survey is very important since it will indicate whether the cathodic protection should be Impressed Current or Sacrificial Anode; the number of stations for the former and the number of anodes for the latter. This leads to an appropriate, cost effective design.

6. Anode Groundbed Survey
For Impressed Current Systems, it is important to locate anode groundbeds near a source of electric power and in an area of low electrical resistivity. The latter is important since the ground is a poor electrical conductor, and the lower the soil resistivity, the smaller the groundbed and hence, the lower the cost.

7. Electrical Continuity Tests
It is essential that the pipeline to be protected is electrically continuous, otherwise uneven and erratic protection will occur. Such a situation can arise with pipelines joined by Viking Johnson couplings, flanges and spigot and socket joints. Welded lines do not present a problem, except at chambers. Continuity tests are similar to current drainage tests since they involve injecting current into the line and measuring the change in potential, or longitudinal resistance. They are sometimes combined with a current drainage test, or more often, carried out separately.

8. AC Mitigation
Modern well coated pipelines in the vicinity of high voltage powerlines may have AC voltages induced on them and it is prudent to carry out tests and calculations to determine these voltages, so that appropriate steps can be taken to reduce them to a safe level.

NOTES

DISA

ANODES (Pty) Ltd.

www.disaanodes.co.za

7 Berg Street
Jeppestown
Johannesburg
SOUTH AFRICA

P.O. Box 33604
Jeppestown
2043

Tel: +27 (0) 11 610-2200/2201
Tel: +27 (0) 11 614-5533/5238
Fax: +27 (0) 11 614-0093
Cell: 083 325 7978
E-mail: sales@disaanodes.co.za

DISA Europe Srl
via Antonio Pellegrino Orlandi n. 11/1
40139 Bologna
ITALY

Tel: +39 051 542 831
Fax: +39 051 624 7004
Mobile: +39 339 523 3862
E-mail: daniela@disaeurope.it

Product Range

- MMO Tubular Anodes
- MMO Mesh Anodes
- MMO Wire
- Magnesium Pipeline Anodes
- Magnesium Ribbon Anode
- Magnesium Rod Anodes For Hot Water Tanks
- Magnesium Disc Anodes
- Zinc Ribbon and Rod Anodes
- Insulating Flanges and Joints
- Spark Gaps
- Coke
- Cables & Cable Splicing Kits
- Reference Electrodes Portable, Permanent and IR Free
- Exothermic Weld Metal and Accessories
- Split Bolts (Line Taps)
- Concrete Test Posts, Plinths and Cabinets
- Coating Repair Materials