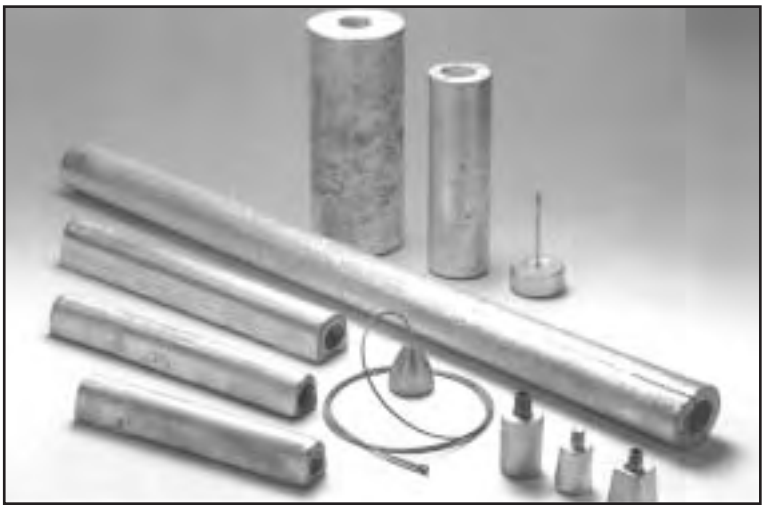
MAGNESIUM ANODES



Applications of magnesium anodes for Cathodic Protection (CP)

Magnesium has the highest driving voltage of the materials used for sacrificial anodes and is most commonly used onshore (in higher resistivity electrolytes) where the use of zinc and aluminium would be uneconomical. The most common applications are:-

Temporary CP Systems

- The high current output of magnesium in seawater assists in the rapid achievement of polarisation potential. This approach has been used where the zinc or aluminium system originally installed has failed to provide sufficient current to achieve polarisation. Recent systems have included magnesium to provide the initial polarisation as part of the system design.
- Temporary protection of land and other pipelines during construction and before the energising of the impressed current system. The anodes are easily installed within the pipe trench as construction proceeds; additional excavation is not required.
- De-scaling of tanks. The high potential and consequent hydrogen evolution at the cathode leads to rapid removal of surface scale.
- External protection of ships' hulls whilst in fresh or brackish water. This often consists of anodes suspended over the vessels' sides.

Permanent CP Systems

- Land pipelines. Magnesium anodes have a particular effective role in urban areas or where there are other buried services in the immediate vicinity.
- Service pipes to domestic and commercial premises. For small diameter and short length pipes, the current required is very low and the anode mass is usually between 0.3 and 1.0kg. Two types of anode are in common use. The first type consists of an insert that screws directly into a "blind tee" that is fitted into the service pipe. This is cheap and easy to install but does not allow the performance to be monitored. The second type consists of a small cast or extruded anode that is packaged in the same way as the larger anode types.
  Connecting the cable via a test point allows for monitoring.
- Short pipelines including river crossings.
- External surfaces of buried storage tanks, particularly oil tanks in hazardous areas.
- External surfaces of caissons in fresh or brackish waters. The higher resistivity of these electrolytes prevents a cost effective protection system using zinc or aluminium anodes.
- Internal surfaces of water storage tanks and treatment plants. The deposits are non toxic and magnesium anodes may be used in potable water systems.
- Internal surfaces of calorifiers, heat exchangers and condensers.
- Protection of "hot spots" on otherwise unprotected pipelines. "Hot Spots" are areas where soil conditions are highly aggressive.
- Supplementary protection on pipelines with impressed current CP systems in poorly protected areas, often due to coating damage.

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- Where space is very limited, for example the internal protection of pipelines or within a narrow pipe trench. In the latter case the use of a continuous or semi-continuous magnesium ribbon usually results in an even current density.

- The protection of short steel/iron pipe lengths or fittings (flanges, valves etc) within non-metallic pipe systems. Some end users require the application of Cathodic Protection to all buried metallic plant. Service anodes are often used for this application.

- As an inexpensive monitoring electrode in large range, high temperature, high resistivity electrolytes, such as water tanks for boiler feed.

Alloys Available

Magnesium anodes are available with several different chemical compositions, but in two basic generic types with voltage outputs of approximately 1.55 and 1.75 volts (with reference to a copper/copper sulphate reference electrode). The performance characteristics for each type are indicated in Table 1.

The 1.75 volt material is an alloy specially formulated from pure virgin magnesium and other elements to produce the higher voltage. It has several advantages over the 1.55 volt material that is often produced from recycled material. In particular, the higher driving potential (about 25-30% greater depending on the Cathodic Protection system design) may allow fewer anodes to be used for a given project. Its higher capacity (up to 4% greater) results in improved performance, with the possibility of longer anode life.:-

Table 1
CCEL magnesium anodes

	Output ($Cu/CuSO_4$)	
	1.55v	1.75v
Chemical Composition		
Aluminium	5.3-6.7%	0.01%max
Zinc (Zn)	2.5-3.5%	-
Copper (Cu)	0.08%max	0.02%max
Silicon (Si)	0.3% max	0.05%max
Manganese (Mn)	0.25%min	0.5-1.3%
Iron (Fe)	0.005%max	0.03%max
Lead (Pb)	0.03%max	-
Other impurities, each	-	0.05%max
Total other impurities	-	0.30%max
Magnesium	Balance	Balance
Capacity (Amp hr/kg)	1230	1230

NB. We can supply any other chemical composition with 1.55V output

Current Output

The following table of current outputs (Table 2) may be utilised in general design calculations and is based upon the following parameters:

i. The current outputs given are approximate only and are calculated taking the polarised potential of the cathode to be 900mV (with reference to a $Cu/CuSO_4$ reference electrode).
ii. The maximum useful life of magnesium alloy anodes is generally limited to about 10/12 years regardless of the theoretical life.
iii. The final steady current output is given in milliamps.

Only the most commonly used packaged anodes are considered in this table. For information on other anodes please ask for separate literature.

Table 2
Current Output

	Anode Nett Weight					
Electrolyte Resistivity Ohm.cm	**4.1kg**		**7.7kg**		**14.5kg**	
	1.55v	**1.75v**	**1.55v**	**1.75v**	**1.55v**	**1.75v**
500	130	170	150	200	180	230
1.000	65	85	75	100	90	120
5.000	15	20	15	20	20	25
10.000	5	10	8	10	10	12

Anode Shape

Best quality anodes can be supplied either circular (vertically cast) or 'D' shaped (horizontally cast).

Diagram 1
'D' Shape Anode

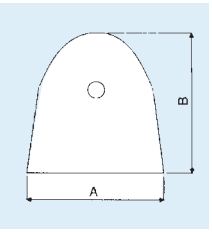
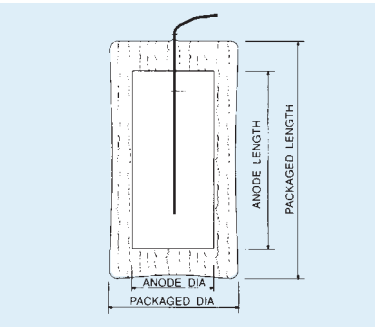


Diagram 2..
Circular Anode



Insert

To ensure complete utilisation of the anode, the insert should be centrally located in the anode and in complete electrical continuity over the entire surface area.

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This is best achieved by using a substantial galvanised steel bar. Galvanising of the insert is recommended to ensure complete steel - zinc-magnesium alloying.
In cylindrical anodes, the insert is normally fitted into the base of a book mould, which forms the connecting well and is vertically located centrally in the mould, subject to little distortion. This is particularly important in long anodes of small cross-section. Positioning of inserts is more difficult to ensure in horizontally cast anodes due to "float" or "sagging" in the molten metal.

Cable Connection to the Insert

The relatively low driving potential of sacrificial anodes means that the electrical resistance in the circuit must be kept as low as possible to ensure maximum current output. For pipeline applications where a cable is used to connect the insert to the cathode, the long term reliability of the insert/cable connection is obviously essential to the continued effective operation of the anode throughout the design life. If the connection resistance increases with time the anode current output will fall and full protection might not be achieved. Depending upon the type of insert that is cast into the anode, there are several methods of making the cable connection. These include direct brazing or welding the cable conductor strands onto the insert, or via a crimped lug to the cable strands, together with a self-tapping screw or screw/nut or pop rivet, fixing to the insert.

Cable

The customer may specify the size and type of cable to be attached. CCEL recommends 3 metres of 6mm sq single core, stranded copper conductor, XLPE insulated, PVC sheathed, 600/1000 volt grade to IEC 502/83 & BS5467 KATHODICA™ Red/Red cathodic protection cable as being suitable for most applications.

Packaged Anodes

Anodes used for pipelines, tanks and buried vessels are usually supplied pre-packaged in a cotton bag surrounded by a special chemical backfill. The environment provided by the backfill helps achieve a more uniform current output and dissolution rate and lowers the resistance to the electrolyte.
Anodes used in low resistivity soils may be supplied unpackaged.

Backfill Composition

Powdered Gypsum	75%
Bentonite	20%
Sodium Sulphate	5%

Other compositions may be provided upon request.

Weights and Dimensions

All anodes are cast to the latest issue manufacturing drawings only. casting dimensions and weights are nominal and are subject to foundry tolerences.

Packaged dimensions and weights are subject to production tolerances and are liable to change due to settlement during transport and handling.

Table 3
Circular magnesium anodes-bare/unpackaged

CCEL Ref	1.55v			1.75v		
	Nett Weight	Dia	Length	Nett Weight	Dia	Length
	kg	mm	mm	kg	mm	mm
AMA-C036	3.6	114	193	3.6	114	202
AMA-C041	4.1	114	220	4.1	114	230
AMA-C050	5.0	114	268	5.0	114	277
AMA-C077	7.7	114	412	7.7	114	431
AMA-C100	10	114	536	10	114	560
AMA-C145	14.5	146	472	14.5	146	494
AMA-C227	22.7	178	497	22.7	178	520
AMA-C273	27.3	178	598	27.3	178	625
AMA-C274	27.3	114	1462	27.3	114	1528

Table 4
Circular magnesium anodes-packaged

CCEL Ref	Gross Weight	Dia.	Length
	kg	mm	mm
AMA-C036P	7	150	425
AMA-C041P	9	150	480
AMA-C050P	11	150	535
AMA-C077P	15	150	580
AMA-C100P	22	165	660
AMA-C145P	30	190	840
AMA-C227P	45	255	760
AMA-C273P	50	255	915
AMA-C274P	50	165	1880

Table 5
D-shaped magnesium anodes- bare

CCEL Ref	1.55v and 1.75v			
	Nett Weight	Dimension A (Diagram 2)	Dimension B (Diagram 2)	Length
	kg	mm	mm	mm
AMA-DO5D2	2.3	70	64.5	305
AMA-DO7D2	3.2	70	64.5	430
AMA-DO9D2	4.1	70	64.5	550
AMA-D14D2	6.35	70	64.5	850
AMA-D17D3	7.7	90	83	650

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Table 6
D-shaped Magnesium Anodes - packaged

CCEL Ref	Gross Wt kg	Dia mm	Length mm
AMA-DO5D2	5	150	500
AMA-DO7D2	7	150	580
AMA-DO9D2	9	150	700
AMA-D14D2	14	150	1040
AMA-D17D3	16	200	1000

Service Anodes

These are often adopted to protect short lengths or gas, oil or water service pipes and maybe used bare or packaged. The bare anodes are supplied with a 1/2" BSP threaded insert that is usually screwed into a "blind tee".

Table 7
Service anode weights and dimensions

CCEL Ref	Nett Weight		Anode Dimensions mm		
	kg	lb	A	B	Length
AMA-S030	0.3	0.66	50	55	80
AMA-S056	0.56	1.26	70	57	102
AMA-S010	1.0	2.21	89	76	102
AMA-RS*	0.17	0.37	500mm Ribbon length		

Magnesium Ribbon

Sometimes used as an alternative to service anodes, magnesium ribbon is extruded in 1.75 volt potential alloy and is usually supplied on a full coil basis (1000ft/ 305m, plus or minus 25ft/8m). Shorter lengths can be supplied upon request.

Chemical Composition

Aluminium (Al)	0.01% max
Copper (Cu)	0.02% max
Manganese (Mn)	0.5-1.3%
Iron (Fe)	0.03% max
Niobium (Ni)	0.001% max
Other impurities, each	0.05% max
Magnesium	Balance

Capacity (Amp. Hour/kg)	1,230
Nominal dims (mm)	19 x 9.5
Core 3.4 mm dia.	Steel rod
Nominal weight	0.361kg/m (0.242 lb)

Approx. current output per m length:

Seawater (25 ohm.cm)	2.5A
Soil (5000 ohm.cm)	12mA
Freshwater (15,000 ohm.cm)	4mA

Rod Anodes

A large range of extruded rod anodes are available with plain ends from 12mm (0.5") to 63mm (2.5") diameter and anodes with threaded end. Details are given in a separate data sheet. Details of the range of extruded rod anodes are given in separate information sheets.

Other Shapes

A wide variety of other anode shapes are available. Typical anodes and their most common applications are shown in tables 8 & 9. All anodes are available in the 1.55 and 1.75 volt alloys.

Table 8
Anodes for low resistivity environments

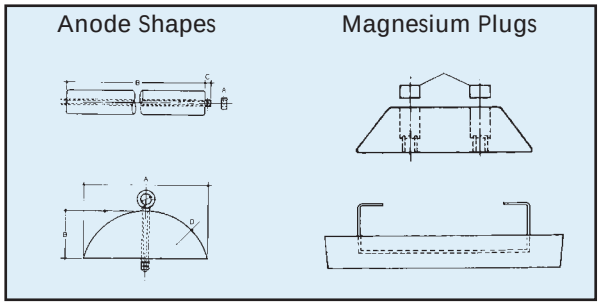
Type	A	B	D	Weight kg
CCEL128	571	219	298	68.0
CCEL129	597	279	298	90.7

Table 9
Anodes for calorifiers and water tanks

Type	A	B	D	Weight kg
CCEL115	114	533	25	10.0
CCEL116	146	533	25	15.5
CCEL117	178	508	25	22.7

Core is 1/2" bore BSP, galvanised steel

Typical Anode Shapes



Quality Assurance

CCEL operate a quality policy to ISO 9001: 2000

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