

MMO Titanium Anode

Introduction

This material consists of a high purity titanium substrate with an applied coating consisting of a mixture serves as a support for oxide coating. Titanium functions as a "valve metal" which forms thin, self-healing, adherent oxide which is acid resistant and resist the passage of anodic current. The oxide is formed substrate by thermal decomposition of precious metal salts that have been applied onto substrate. The special coating activates the anode and provides excellent electro catalytic properties. Comparing with conventional impressed current anodes, the anodes are small, lightweight and with extreme low consumption rate of less than 1.0 mg/A.yr.



Application

MMO titanium anodes perform well in all types of environment including areas with extremely low pH level (under 1), and high chloride concentrations. Their unique configuration makes the anodes

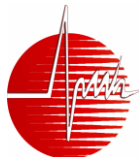
Ideal for use in a wide variety such as cathodic protection system for buried structures, pipeline, ship, jetties & wharf And steel in concrete

Anode Life	Maximum Current Density	Electrolyte
25 years	50 A/m ²	Carbonaceous Backfill
25 years	100 A/m ²	Calcined Petroleum Coke
25 years	100 A/m ²	Fresh Water
25 years	300 A/m ²	Brackish Water
25 years	600 A/m ²	Sea Water

Anode Shapes

MMO anodes are available in different shapes like Rod, Tubular, Plate, Disc and Mesh anodes.





MMO Coated Titanium Ribbon Anode & Titanium Conductor Bar

MMO Coated Titanium Ribbon anodes are widely used for External Cathodic Protection of Ongrade Storage tanks along cathodic protection of steel reinforcement for Concrete.

The MMO activated Ribbon will act as Anode, while Titanium bars interconnected with anode segments is used as conductor for adequate distribution of protective current to the anode grid.

Titanium substrate of Ribbon anode and the conductor bar meet ASTM B265 Grade 1 Standards.

The mixed metal oxides are formed on the substrate through a process of thermal- decomposition, creating a coating from combination of Iridium dioxide (IrO₂) and Tantalum pentoxide (Ta₂O₅).



Advantages

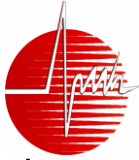
- Lightweight
- high chemical stability even in environments with very low PH values.
- extremely low and uniform wear rate, between 1 and 6 milligrams/ampere-year.
- stability of dimensions during the design life .
- high current density.
- The superior electrically-conductive performance.

Current Output of Ribbon in Fine Sand:

12.8mA/ft (42mA per m) when operating at an anode current density of .278 A/ft² (3 A/m²) for 50 year + design life.

Data sheet:

Anode Data			
Geometry	Ribbon (6.35mm Width x 0.635mm Tick)	Coating Thickness	1 Micro-meters 20% Tolerance
Activation	Mixed Metal Oxide (IrO ₂ :Ta ₂ O ₅)	Environmental Condition	Soil temp: max +60°C min -10°C 1-9 pH with Evolution O ₂ , Cl ₂ or a combination of both
Substrate Type	Titanium base Material, Comply to ASTM B265 standards		
Coating loadings	3Amps/Sq.m or 42mA/m length	Design Life	50 Years +
Conductor Bar			
Geometry	Strip Bar (12.7mm Width x 0.9mm Tick)	Coating Thickness	N/A
Material Standard	Titanium base Material, Comply to ASTM B348 or ASTM B265 standards	Environmental Condition	Soil temp: max +60°C min -10°C Elector light :1-9 pH



Piggyback MMO Wire Anode

Technology for Cathodic Protection of underground pipeline has undergone fundamental innovation allowing optimization and close to ideal current distribution.

MMO activated Wire anodes technology provide optimized current distribution, low grounded resistance and better than ever power efficiencies.

Wire anodes supported by suitable rated Carrier Cable, called Piggyback Anode has low electronic resistance plus connection spacing per required specification will have no greater attenuation than 10% in grounding installations.

Depending to the required protective current demands, soil resistivity and site conditions, Piggyback anode design can usually be altered to accommodate Cathodic Protection system requirements by means of;

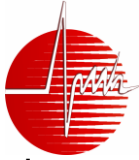
- Wire Anode diameter,
- Carrier Cable sizing,
- Cable to anode connections
- Backfilling material.

Wire anode is mostly supplied in 152 meters long coils and multiple lengths of wire anodes shall be suitably spliced for longer anodes.

The current Carrier Cable are joined in parallel to the Wire anode minimizes attenuation of Piggyback anode. The Carrier cable should be considered large enough to carry the current without significant voltage drop.

Depending on the application the anode can be used with or without Backfilling Sock.





Piggyback Anode Features:

- Follows Pipeline symmetry
- Optimized for current Distribution
- Optimized Power Efficiency
- Optimized for low grounded resistance
- Easy to install
- >50 year Anode design life
- Cost effective
- Arrives ready to lay in place

Piggyback Anode Datasheet

Anode Data			
Geometry	Wire, Dia: 1.5 or 3 mm	Soil temp	max +60°C min -10°C,
Substrate Type	Titanium ASTM B348	Environment	O ₂ , Cl ₂ or combination of both
Coating loadings	3 A/Sq.m	Electrolyte	1-9 pH
Catalyst			
Activation	Mixed Metal Oxide (IrO ₂ :Ta ₂ O ₅)	Thickness	1-1.2 Micro-meters
Catalyst On Anodes	By thermal decomposition	Colour	Black
Design Spec			
Design Life	Minimum of 30+ Years at 3Amps/Sq.m	Carrier Cable	To be calculated based on Project Requirements
Test & Inspection			
<ul style="list-style-type: none"> • Dimensional inspection report • Chemical Analysis of Titanium • X Ray test of MMO Coating • Accelerated life test 			



High Silicon Chromium Cast Iron Anodes 3" × 60"

ARMIN's High Silicon Chromium Iron anode is a solid, non-porous Impressed Current Anode. This anode alloy consists of matrix of Silico-Ferrite in which the majority of carbon is in the form of graphite flakes at grain boundaries. Adding chromium results in eliminating graphite.

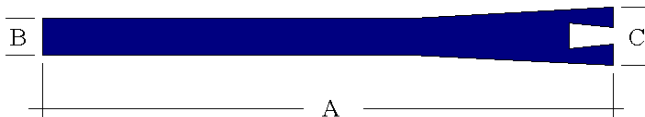
For over Four decades High Silicon Cast Iron Anodes have been used successfully in the cathodic protection industry and is one of the most reliable protection materials available. The consumption rate of High Silicon Chrome Cast Iron anodes has been found to be between 0.2 and 1.2 pounds per ampere-year. A generally accepted design guideline for anodes buried in coke breeze is 0.7 pounds per amp-year. These anodes are available in a number of different styles including solid rod anodes, center connected tubular anodes, and other specialty configurations.



Solid 3" × 60" Rod anodes

Typically used for shallow applications, solid rod high silicon cast iron anodes are low cost solutions to your cathodic protection needs.

Dimensions and Weight



Total length -A-	mm	1520
Diameter -B-	mm	76
Diameter -C-	mm	101
Surface Area	m ²	0.38
Total Weight	kg	49.1

Chemical Composition (ASTM A518 Grade 3)

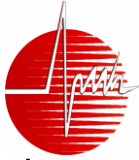
Element	Composition wt%
Si	14.20 – 14.75
Mn	Max 1.5
C	0.70 – 1.10
Cr	3.25 – 5.00
Mo	Max 0.20
Cu	Max 0.50
Fe	Balance.

Physical Characteristics

Density	7.0 -7.05	g/cm ³
Compressive Strength	650	Mpa
Brinell Hardness	500	-
Electrical Resistivity	72	μ Ω . cm

Electrical Properties

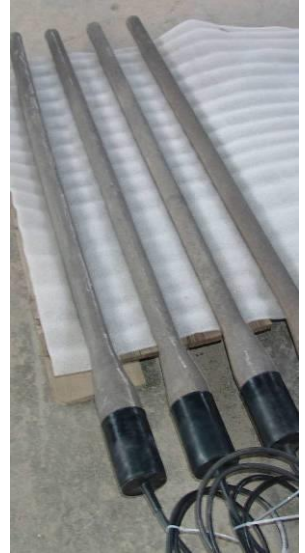
Environment	Current Density A/m ²	Consumption Rate Kg/A year	Efficiency %
Freshwater	10	0.15	90
Saltwater	30	0.50	90
Soil	10	0.25	90



High Silicon Chromium Cast Iron Anodes 2" × 60"

ARMIN's High Silicon Chromium Iron anode is a solid, non-porous Impressed Current Anode. This anode alloy consists of matrix of Silico-Ferrite in which the majority of carbon is in the form of graphite flakes at grain boundaries. Adding chromium results in eliminating graphite.

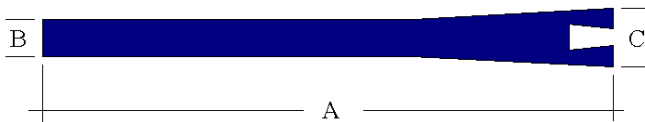
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Solid 2" × 60" Rod anodes

Typically used for shallow applications, solid rod high silicon cast iron anodes are low cost solutions to your cathodic protection needs.

Dimensions and Weight



Total length -A-	mm	1520
Diameter -B-	mm	50
Diameter -C-	mm	76
Surface Area	m ²	0.25
Total Weight	kg	22.7

Chemical Composition (ASTM A518 Grade 3)

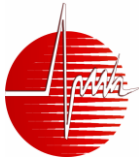
Element	Composition wt%
Si	14.20 – 14.75
Mn	Max 1.5
C	0.70 – 1.10
Cr	3.25 – 5.00
Mo	Max 0.20
Cu	Max 0.50
Fe	Balance.

Physical Characteristics

Density	7.0 -7.05	g/cm ³
Compressive Strength	650	Mpa
Brinell Hardness	500	-
Electrical Resistivity	72	μ Ω . cm

Electrical Properties

Environment	Current Density A/m ²	Consumption Rate Kg/A year	Efficiency %
Freshwater	10	0.15	90
Saltwater	30	0.50	90
Soil	10	0.25	90



High Silicon Chromium Cast Iron Anodes

ARMIN's High Silicon Chromium Iron anode is a solid, non-porous Impressed Current Anode. This anode alloy consists

of matrix of Silico-Ferrite in which the majority of carbon is in the form of graphite flakes at grain boundaries. Adding chromium results in eliminating graphite.

For over Four decades High Silicon Cast Iron Anodes have been used successfully in the cathodic protection industry and is one of the most reliable protection materials available. The consumption rate of High Silicon Chrome Cast Iron anodes has been found to be between 0.2 and 1.2 pounds per ampere-year. A generally accepted design guideline for anodes buried in coke breeze is 0.7 pounds per amp-year. These anodes are available in a number of different styles including solid rod anodes, center connected tubular anodes, and other specialty configurations.

Tubular Anodes

Center Connected Tubular anodes are typically used for Deep Anode grounded applications, Tubular high silicon cast iron anodes are one of the best solutions to your cathodic protection needs. These anode can also be utilized in variety of electrolytes, from soil and fresh water to brackish and salt water environments. it is suitable for use in deep and conventional ground bed applications.

Nominal Weight & Dimension of Tubular Anodes

Type	Specification (mm)	Surface (m ²)	Weight (kg)
TA1	67×1067	0.22	14.1
TA2	56×2133	0.37	20.9
TA3	67×2133	0.46	28.6
TA4	95×2133	0.64	38.6
TA5	121×2133	0.81	49.9

Composition (ASTM A518 Grade 3)

Element	Composition wt%
Si	14.20 – 14.75
Mn	Max 1.5
C	0.70 – 1.10
Cr	3.25 – 5.00
Mo	Max 0.20
Cu	Max 0.50
Fe	Balance.

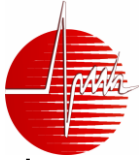
Physical Characteristics

Density	7.0 -7.05	g/cm ³
Compressive Strength	650	Mpa
Brinell Hardness	500	-
Electrical Resistivity	72	μ Ω . cm

Electrical Properties

Environment	Current Density A/m ²	Consumption Rate Kg/A year	Efficiency %
Freshwater	10	0.15	90
Saltwater	30	0.50	90
Soil	10	0.25	90





Canister MMO Titanium Anode

Introduction

Canisters are pre-packed anodes. For convenience and easier installation, anodes are installed in a spirally wound 0.7-0.8 mm thick galvanized steel canister. The canister MMO anode is packed and compacted firmly by Calcined Petroleum Coke to ensure even current transfer from the anode.

Benefits

- Reduce the resistance of anode to ground
- Extend the life of anode
- Improve the contact between anode and surrounding soil
- Provide higher current output



The galvanized steel canisters form part of the anode and will be consumed in service. Due to the sacrificial effect between the canister and the coke, it is advised that storage time be kept to a minimum so as to avoid corrosion and perforation of the canister.

Application

MMO titanium anodes perform well in all types of environments including areas with extremely low pH levels (under 1), and high chloride concentrations. Their unique configuration makes the anodes ideal for use in a wide variety of environments such as the protection of buried pipelines, ship, jetties & wharf and steel in concrete. MMO anodes are also used as replacement anodes for above ground on grade storage tanks.

Anode Specifications

Shape	Dimensions		Application	Design Life	Current Output	Substrate Material	Coating Material
	Dia.	Length					
Tubular	25.4 mm	1000 mm	Petroleum Coke Backfill	25 Years	8 A	Titanium Tube	IrO ₂ -TaO ₅

Canister Dimensions



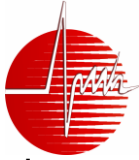
Diameter (mm)	150
Length (mm)	1800
App. weight (kg)	42

Coke Backfill

Min. carbon Con.	98 wt%
Max. Resistivity	0.5 Ohm.cm
Density	900 kg/m ³
Particle Size	90% 0.1-5.0 mm

Cable specifications

Anodes would be supplied with 1×16 mm² HMWPE/PVDF (KYNAR) cable tail.



Canister High Silicon Cast Iron Anodes

Canisters are pre-packed anodes. For convenience and easier installation, anodes are installed in a spirally wound 0.7-0.8 mm thick galvanized steel canister. The canister Silicon Cast Iron Anode is packed and compacted firmly by metallurgical coke to ensure even current transfer from the anode.



Benefits

- Reduce the resistance of anode to ground
- Extend the life of anode
- Improve the contact between anode and surrounding soil
- Provide higher current output

Unless proper care is taken to ensure good contact between canister and native soil, abnormally high resistance will occur in cases where pre-packed anodes are installed to reduce the resistance of anode bed in hard and rocky grounds.

The galvanized steel canisters are biodegradable and will corrode in service and used as transit package only. It should be stored in a dry place before installation to avoid corrosion and perforation.

Canister Dimensions



Standard Container	Diameter (mm)	Length (mm)	App. Weight (kg)
CAN 18/16	160	1800	50
CAN 20/20	200	2000	85
CAN 20/30	300	2000	110

Coke Backfill

Min. carbon Con.	80 wt%
Max. Resistivity	50 Ohm.cm
Density	800 kg/m ³
Particle Size	90% 0.1-10.0 mm

Cable specifications

Anodes would be supplied with 1×16 mm² XLPE/PVC cable tail.



Aluminum Anodes

Aluminum anodes offered by ARMIN are designed for optimum performance under a variety of environmental conditions and temperature ranges.

Available sizes - Aluminum anodes are available in a variety of sizes, weights and configurations. Depending on the application one of these available anode configurations should provide a reliable solution. However, if special applications are encountered, custom fabricated anodes can be made to suit your needs.

Anode core – Each anode is typically cast with a steel core suited for the application or installation of the anode. Core types include flat bars, solid rods, pipe cores, threaded rods, eyebolts and other customized cores.

Anode life – As with any other anodes, anode life depends on the current output of the anode. The more current output provided by the anode, the shorter the anode's life. Therefore, it is important to consider a number of factors when selecting the type and quality of anodes. These factors include electrolyte resistivity, structure surface area, coating integrity, temperature, and design life.

Standards – Anodes to be design in accordance to DNV-RP-F103 are produced from min of 99.85% pure Aluminum base material complying DNV-RP-B401 & ISO 15589 electro-chemical properties are inspected according to NACE RP387 standard requirements.

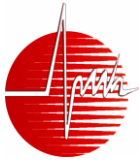


Chemical Composition

<i>Element</i>	<i>Content wt%</i>
Fe	0.09 max
Si	0.12 max
Cu	0.003 max
Zn	2.5 ~ 5.75
In	0.016 ~ 0.040
Cd	0.002 max
Others	0.02 (Each) max
Al	Remainder

Electrical Properties (Sea water at 25 Ohm.Cm)

Min. Current Capacity	2500 AH/Kg
Utilization Factor	90%
Close Circuit Potential	-1.05V (vs Ag/AgCl)
Protective Potential	-0.80V (vs Ag/AgCl)








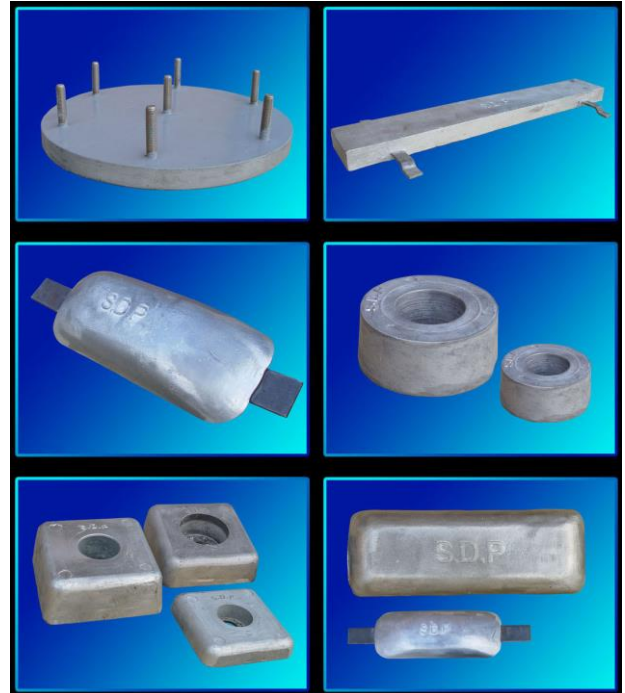
Zinc Anodes

Zinc anodes are an effective and economical corrosion fighter. They are frequently used in seawater or saline mud, to protect ship hulls, ballast tanks, bulkheads, piers, pilings and heat exchangers. In addition, zinc anodes are also used underground to protect buried steel structures.

ARMIN provides a full line of zinc anodes, for all applications, manufactured to your exacting project specifications. Our careful attention during the alloying process assures you of a complete line of zinc anodes that provide maximum protection to your structure.

ARMIN provides a complete line of zinc anodes for these applications:

-  Condenser Anodes
-  Hull Anodes
-  Ballast Tank Anodes
-  Piers
-  Pilings

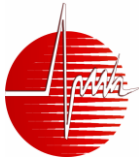


Chemical Composition

<i>Element</i>	<i>Content wt%</i>	
	<i>Type I</i>	<i>Type II</i>
Al	0.1 - 0.5	0.005 max
Cd	0.02 - 0.07	0.003 max
Fe	0.005 max	0.0014 max
Pb	0.006 max	0.003 max
Cu	0.005 max	0.002 max
Zn	Remainder	Remainder

Electrical Properties

<i>Type</i>	<i>Type I</i>	<i>Type II</i>
OCP (V vs. Ag/AgCl)	- 1.05	- 1.10
Max Current Capacity	780 Ah/kg	730 Ah/kg



Magnesium Anodes

Magnesium anodes are employed in many sacrificial anode systems, due to their light weight and high output ratings. They are an economical choice for underwater or underground applications, especially in environments with high electrical resistance.

ARMIN's magnesium anodes come in a full array of shapes and sizes to fit any cathodic protection application. The underground anodes may be ordered bare or packaged, depending on your project specifications.

ARMIN's magnesium anodes are available for the following applications:

- Heat exchangers
- Condensers
- Boilers



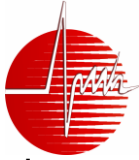
ARMIN's Magnesium anodes are available in Hi-potential and 3 standard grades with the chemical composition as following:

Chemical Composition

<i>Element</i>	<i>Content wt%</i>			
	<i>High Potential</i>	<i>Grade I</i>	<i>Grade II</i>	<i>Grade III</i>
Al	0.01	5.3-6.7	5.3 - 6.7	5.0 - 7.0
Mn	0.5-1.3	0.15 -0.7	0.15 – 0.7	0.15 – 0.7
Zn	-	2.5 - 3.5	2-5 - 3.5	2.0 - 4.0
Si	0.05	0.10	0.30	0.30
Cu	0.02	0.02	0.05	0.10
Ni	0.001	0.002	0.003	0.003
Fe	0.03	0.003	0.003	0.003
Other total	0.30	0.30	0.30	0.30
Mg	<i>Reminder</i>	<i>Remainder</i>	<i>Remainder</i>	<i>Remainder</i>

Electrochemical Properties

<i>Type</i>	<i>High Potential</i>	<i>Standard Grade I</i>
OCP (V vs. Ag/AgCl)	-1.75	-1.55
Max Current Capacity	1100 Ah/Kg	1100 Ah/Kg






Pre-packaged Magnesium Anodes

Magnesium anodes for buried pipelines, casings, tanks and similar structures are supplied packaged in a cotton bag containing a rapid wetting, moisture retaining backfill.

The backfill powder reduces the soil resistivity surrounding the anodes and improves the anode performance.

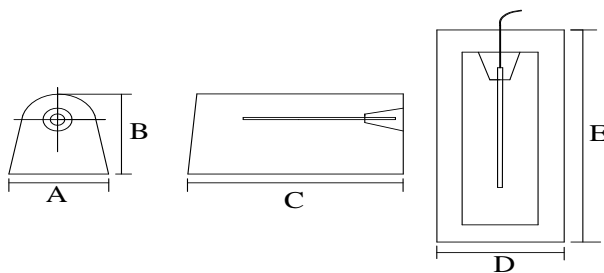
The pre-packaged magnesium anodes are available in two grades, standard and High-potential, which is used primarily in high resistivity soils. Anodes are supplied different length of insulated copper cable on request.

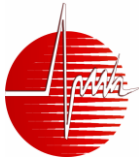
Standard backfill composition:

-  Powdered Gypsum : 75%
-  Granular Bentonite : 20%
-  Sodium Sulphate : 5%

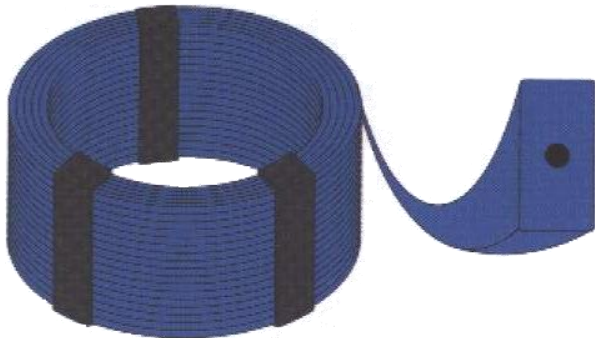
Standard Dimensions

Anode Type	Bare Weight, lb	Packaged Weight, lb	Bare			Packaged	
			A	B	C	D	E
ARM.1.1.Mg.1	1	5	1-3/4"	1-3/4"	8"	3 1/4"	10"
ARM.1.2.Mg.3	3	9	3-1/2"	3-1/2"	5-1/4"	5 1/2"	10"
ARM.1.3.Mg.5	5	14	3-1/2"	3-1/2"	9-1/4"	5 1/2"	14"
ARM.1.4.Mg.9	9	35	2-3/4"	2-3/4"	26-1/4"	6"	31"
ARM.1.8.Mg.17	17	60	2-3/4"	2-3/4"	50-1/4"	6"	55"
ARM.1.9.Mg.20	20	72	2-3/4"	2-3/4"	56-3/4"	5-1/2"	66"
ARM.1.10.Mg.24	24	60	4-3/4"	4-3/4"	23-1/2"	7"	30"
ARM.1.11.Mg.32	32	90	3-3/4"	4"	47"	6-1/2"	53"
ARM.1.13.Mg.40	40	105	3-3/4"	4"	56-1/2"	6-1/2"	66"
ARM.1.14.Mg.48	48	98	5-1/2"	5-3/4"	30-1/4"	8"	38"
ARM.1.15.Mg.60	60	125	4-3/4"	4-3/4"	57-1/2"	7"	64"

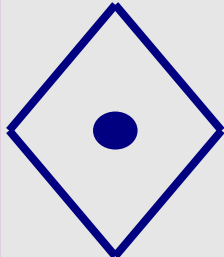
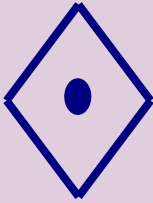








Sacrificial Ribbon Anodes



A sacrificial anode shapes having the maximum surface area to mass ratio, therefore providing a high current output. Ribbon anodes are particularly suitable for high resistivity environments. Anodes of magnesium, zinc and aluminum are available to suit many cathodic protection requirements.

<i>Zinc</i>				
<i>Code</i>	<i>Super</i>	<i>Plus</i>	<i>Standard</i>	<i>Smal</i>
<i>Section</i>	1" × 1-1/4 "	5/8" × 7/8 "	1/2" × 9/16 "	11/32" × 15/32 "
<i>Core diameter</i>	0.185"	0.135"	0.130"	0.115"
<i>Weight</i>	3.57 kg/m	1.79 kg/m	0.89 kg/m	0.37 kg/m
<i>Coil length</i>	Approx. 30 m	Approx. 60 m	Approx. 150 m	Approx. 300 m

<i>Magnesium</i>		
<i>Code</i>	<i>3.4 MR</i>	<i>2.8 MR</i>
<i>Section</i>	1" × 1-1/4 "	5/8" × 7/8 "
<i>Core diameter</i>	0.185"	0.135"
<i>Weight</i>	3.57 kg/m	1.79 kg/m
<i>Coil length</i>	Approx. 30 m	Approx. 60 m

All dimensions and weight are nominal. Longer coil lengths are available on request.