

Australian Standard™

**Galvanic (sacrificial) anodes for
cathodic protection**



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- Australasian Institute of Metal Finishing
- Australian Chamber of Commerce and Industry
- Australian Electrolysis Committee
- The Australian Gas Association
- Australian Paint Manufacturers' Federation
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- Bureau of Steel Manufacturers of Australia
- Corrosion Prevention Centre
- Department of Defence
- Division of Building, Construction and Engineering, CSIRO
- Galvanizers Association of Australia
- Telstra
- United Water International
- Water Services Association of Australia

Additional interests participating in the preparation of this Standard:

- Corrosion consultants
- Department of Minerals and Energy
- Gas and Fuel Corporation of Victoria
- Hunter Water Board
- Petroleum refineries
- State Electricity Commission of Victoria
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This Standard was issued in draft form for comment as DR 03185.

STANDARDS AUSTRALIA

RECONFIRMATION
OF
AS 2239—2003
Galvanic (sacrificial) anodes for cathodic protection

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Technical Committee MT-014 has reviewed the content of this publication and in accordance with Standards Australia procedures for reconfirmation, it has been determined that the publication is still valid and does not require change.

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NOTES

Australian Standard™

Galvanic (sacrificial) anodes for cathodic protection

Originated as AS 2239—1979.
Previous edition AS 2239—1993.
Third edition 2003.

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Published by Standards Australia International Ltd
GPO Box 5420, Sydney, NSW 2001, Australia
ISBN 0 7337 5574 7

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PREFACE

The Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-014, Corrosion of Metals to supersede AS 2239—1993, *Galvanic (sacrificial) anodes for cathodic protection*. After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian, rather than an Australian/New Zealand Standard.

The objective of this Standard is to specify the requirements for those common anode alloys available in Australia for use in cathodic protection systems, such as those specified in the AS 2832 series of Standards.

The objective of this revision is to include new specifications and chemical composition limits for anodes.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the appendix to which they apply. A ‘normative’ appendix is an integral part of a Standard, whereas an ‘informative’ appendix is only for informative and guidance.

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STANDARDS AUSTRALIA

Australian Standard**Galvanic (sacrificial) anodes for cathodic protection**

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for galvanic (sacrificial) anodes for use in the cathodic protection of metals against corrosion. It specifies the composition of suitable alloys for magnesium, zinc and aluminium anodes and gives details of shapes and design features of some commonly used anodes. It also includes details of backfill compositions and properties, for buried magnesium and zinc anodes.

NOTE: Advice and recommendations on information to be supplied by the purchaser at the time of enquiry or order are contained in the purchasing guidelines set out in Appendix A.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

1042 Direct-acting indicating electrical measuring instruments and their accessories

1152 Specification for test sieves

1627 Metal finishing—Preparation and pretreatment of surfaces

1627.9 Part 9: Pictorial surface preparation standards for painting steel surfaces

2706 Numerical values—Rounding and interpretation of limiting values

2832 Cathodic protection of metals

2832.4 Part 4: Internal surfaces

AS/NZS

1125 Conductors in insulated electric cables and flexible cords

3008 Electrical installations—Selection of cables

3008.1.1 Part 1.1: Cables for alternating voltages up to and including 0.6/1 kV—Typical Australian installation conditions

ASTM

D1141 Standard practice for the preparation of substitute ocean water

MIL-A

18001k Anodes, corrosion preventive, zinc; slab disc and rod shaped

1.3 DEFINITIONS

For the purpose of this Standard, the definitions below apply.

1.3.1 Anode (in general)

An electrode, placed in the electrolyte, to apply cathodic protection to the structure.

1.3.2 Anode backfill

Material surrounding and in contact with a buried anode to maintain or improve its performance.

1.3.3 Anode consumption rate

The rate of alloy mass consumption for a given current output over a given period; normally stated in kilograms per ampere year.

1.3.4 Anode core

A metal insert (usually steel) either cast into the anode or extruded with the anode to provide mechanical strength and attachment.

1.3.5 Cathode

The structure that is to be protected by cathodic protection.

1.3.6 Cathodic protection

The prevention or reduction of corrosion of metal by making the metal the cathode in a galvanic or electrolytic cell.

1.3.7 Closed circuit potential

The potential of an anode connected to a structure when passing current; normally measured against a reference electrode in a particular environment.

1.3.8 Copper/copper sulfate (Cu/CuSO₄) reference electrode

A reference electrode consisting of copper in a saturated solution of copper sulfate.

1.3.9 Current capacity

The total current flow available from an anode of given mass of alloy; normally expressed as ampere years per kilogram. This is the inverse of the anode consumption rate.

1.3.10 Current density (at anode)

Current output of anode divided by the anode surface area.

1.3.11 Current density (at cathode)

Current flowing into cathode divided by the cathode surface area.

1.3.12 Current density (at coated cathode)

Total current flow into cathode divided by the total surface area of the structure.

1.3.13 Driving potential

The difference between the open circuit potentials of the anode and the structure.

1.3.14 Electrolyte

A liquid, or the liquid component in a composite material such as soil, in which electric current may flow by ionic charge transfer.

1.3.15 Galvanic action

A spontaneous electrochemical cell reaction in which a metallic anode in a dissimilar metal couple corrodes.

1.3.16 Galvanic anode

An electrode used to protect a structure by galvanic action.

1.3.17 Gross anode mass

Total mass of an un-packaged anode, including core, cable and connection.

1.3.18 Gross anode packaged weight

Total mass of a packaged anode, including core, cable, connection and backfill.

1.3.19 Net anode mass

Mass of actual anode alloy.

1.3.20 Open circuit potential

The potential of an anode when not connected to a structure; normally measured against a reference electrode in a particular environment.

1.3.21 Packaged anode

Either a magnesium or zinc anode placed, with backfill, in a calico bag or other approved container to provide a uniform low resistivity environment for the anode.

1.3.22 Reference electrode

An electrode which has a stable potential in one or more electrolytes at a given temperature, thus enabling it to be used for the measurement of other electrode potentials.

1.3.23 Resistivity

Resistance per unit length through a unit area cross-section, (ohm.m).

1.3.24 Silver/silver chloride reference electrode (Ag/AgCl)

An electrode consisting of silver, coated with silver chloride, in an electrolyte containing chloride ions.

1.3.25 Test anode

A prepared anode test piece, made from a test specimen by a mechanical operation.

1.3.26 Test sample

A portion of material or a group of items selected from a batch or consignment by a sampling procedure.

1.3.27 Test specimen

A portion of material or a single item taken from the test sample for the purpose of applying a particular test.

1.4 DESIGNATION**1.4.1 Anodes**

The anode designation shall consist of the following components:

- (a) A prefix number or numbers indicating the net alloy mass.
- (b) A letter indicating the alloy material as follows:
 - (i) A aluminium.
 - (ii) M magnesium.
 - (iii) Z zinc.
- (c) The series number of the alloy.

Example of designation: 10Z1 indicates a 10 kg anode of alloy Z1, the first alloy in the series.

1.4.2 Backfill

Backfill surrounds for anodes shall be designated in accordance with their composition, as follows:

- (a) B1 calcium bentonite/gypsum.
- (b) B2 sodium bentonite/gypsum.
- (c) B3 as for Items (a) or (b) with additions of sodium sulfate.

1.5 FREEDOM FROM DEFECTS

Anodes shall be produced from primary metal alloys. No secondary metal or scrap shall be used, with the exception of house generated scrap from rejected anodes during the forming process.

Defects shall not affect the performance or function of the anodes in service. Anodes shall be free of inclusions or defects which could cause the loss of electrical contact, the flaking of surface metal or any other adverse effects.

NOTE: Defects such as inclusions, segregation or surface flaws cannot be completely quantified. Where the presence, size or frequency of any of these are considered to be of concern, arrangements should be made between the purchaser/regulatory authority/certifying body (as appropriate), and the manufacturer. This may be achieved by the provision of acceptable type samples or methods of test.

Where defects are present and the product is submitted for acceptance, the manufacturer should be able to demonstrate fitness for use.

1.6 MARKING

The following information shall be legibly and durably marked on each anode or group of anodes supplied, or on a label securely fixed to each anode, unless otherwise requested by the customer:

- (a) The name or registered mark of the manufacturer or supplier.
- (b) The alloy designation.
- (c) Nominal net mass of the anode and, in the case of a packaged anode, the gross anode package weight.
NOTE: Gross mass also includes the mass of the cable attached to the anode.
- (d) If appropriate, the instruction 'remove plastic bag prior to installation of the anode'.
- (e) The backfill composition.

NOTE: Manufacturers making a statement of compliance with this Australian Standard on a product, packaging, or promotional material related to that product, are advised to ensure that such compliance is capable of being verified.

1.7 ROUNDING OF TEST RESULT VALUES

For the purpose of assessing compliance with this Standard, the specified limiting values herein shall be interpreted in accordance with the rounding method described in AS 2706, i.e. the observed or calculated value shall be rounded to the same number of figures as in the specified limiting value and then compared with the specified limiting value.

SECTION 2 ANODE AND CORE REQUIREMENTS

2.1 SCOPE OF SECTION

This Section specifies requirements for anodes, cores, core cables and cable attachment, describes the type and shapes of magnesium, zinc and aluminium anodes, and provides guidelines on how they should be selected and applied for cathodic protection.

2.2 ANODES

2.2.1 Anode composition

The chemical composition of the anode shall comply with the limits given in Tables 2.1, 2.2 and 2.3, as appropriate.

2.2.2 Anode mass and dimensions

Galvanic anodes are available in a variety of forms and masses.

NOTE: Appendix B describes typical anode forms and lists the masses and nominal dimensions.

2.3 CORES

2.3.1 Placement of anode core

For cast anodes, the core cover shall not be less than 10 mm thick. The exception being rod anodes where the core is placed centrally.

Unless otherwise specified, the anode shall be designed with the core located centrally, within 10% of the axis, within the surrounding anodic material to enable the anode to corrode as evenly as possible around the core. The position of the anode core shall be such that the maximum possible mass of anode material is available to provide cathodic protection.

NOTE: Information on core sizes is given in Appendix B.

2.3.2 Materials and finish

Requirements need to be discussed between the purchaser and manufacturer in regards to the required finish of anode core materials.

Cores shall be abraded or otherwise treated to ensure that the requirements of Clauses 3.2, 3.3 and 3.4 shall be achieved. All insert material shall be free from rust, mill scale, oil and any other contaminants.

The following materials and finishes are used for the manufacture of cores:

- (a) Extruded magnesium—steel wire cold drawn.
- (b) Cast magnesium—steel rod or flats either clean mill finish or abrasive blasted to Class 2, Class 2.5 or Class 3 as specified by AS 1627.9.

Zinc coatings shall not be used on steel core of magnesium alloy anodes.

- (c) Extruded or cast zinc—zinc coated steel wire, mill finish steel rod or flats. Abrasive blasted mill finish steel rod or flats. Electroplated zinc coated steel and hot dip galvanized steel.

NOTE: Aluminium inserted cores may be used for cast zinc anodes where the anode is used to protect aluminium.

- (d) Extruded aluminium—steel wire, cold drawn.
- (e) Cast aluminium—Steel rod flats either clean mill finish or abrasive blasted to Class 2, 2½ or Class 3 as specified by AS 1627.9.

Zinc coatings shall not be used on the steel core of aluminium alloy anodes.

2.3.3 Bonding of core to anode

Cores shall be thoroughly dried prior to manufacture of the anode. For blast cleaned steel cores, casting shall proceed within 48 hours of blast cleaning. If any visible signs of flash rusting appear by the time casting is to commence, the steel cores shall be re-cleaned.

Wire used as core material shall be free of grease and oil, which, if present, can cause bubbling in the anode material and lack of bond between the core and the anode.

2.3.4 Methods of attachment of cable for buried anodes

For buried anodes, a length of 7/1.04 insulated copper cable conforming to AS/NZS 3008.1.1, or other appropriately insulated copper cable, shall be attached to the anode core by an appropriate method. The method of attachment shall provide compliances with the mechanical requirements specified in Clause 3.2. Typical methods of attachment are as follows:

- (a) *For magnesium anodes* For magnesium anodes, typical methods of attachment are shown in Figures 2.1, 2.2, 2.3 and 2.4. After attachment, a mastic/adhesive-lined polyethylene heat-shrink sleeve is applied to protect the joint mechanically. A crimped connection may be encapsulated with epoxy resin for this purpose.
- (b) *For anodes other than magnesium* A typical method of attachment are shown in Figures 2.2, 2.3 and 2.4. After attachment, a mastic/adhesive-lined polyethylene heat-shrink sleeve is applied to protect the joint mechanically. A crimped connection may be encapsulated with epoxy resin for this purpose.

NOTES:

- 1 Anodes exceeding 25 kg in nett weight should be suspended by means other than by the connection cable.
- 2 Methods of attachment of cables for anodes suspended in water require special designs and are outside the scope of this Standard. Guidelines for cable attachment in tanks and reservoirs are provided in AS 2832.4.

2.3.5 Colour of cable insulation

The colour of the insulation of anode cables shall be red, unless otherwise specified by the purchaser.

TABLE 2.1
CHEMICAL COMPOSITION LIMITS FOR MAGNESIUM ALLOY ANODES

Element	Chemical composition, %					
	Cast or extruded high potential		Extruded low potential		Cast low potential	
	Designation M1		Designation M2		Designation M3	
	Min.	Max.	Min.	Max.	Min.	Max.
Aluminium	—	0.01	2.5	3.5	5.3	6.7
Zinc	—	0.02	0.7	1.3	2.5	3.5
Manganese	0.50	1.3*	0.20	1.5	0.25	0.40
Silicon	—	0.05	—	0.05	—	0.05
Copper	—	0.02	—	0.006	—	0.05
Iron	—	0.03	—	0.003	—	0.03
Nickel	—	0.001	—	0.001	—	0.003
Calcium	—	0.04	—	0.04	—	0.04
Other impurities						
— each	—	0.05	—	—	—	—
— total	—	0.30	—	0.30	—	0.30
Magnesium	remainder		remainder		remainder	

* In the range 0.50 to 0.80%, the percentage of manganese is required to be at least 0.5 + (60 × % aluminium).

NOTES:

- 1 Alloy M1 is a high potential anode material and is used in high resistivity soils and waters.
- 2 Alloys M2 and M3 are low potential anode materials and are used in medium resistivity soils and water. Alloy M2 is also used in hot-water applications for temperatures up to 85°C.
- 3 In order to minimize self-corrosion of alloy M2 when used in domestic water storage heater applications, it has been found desirable to maintain the iron content below 0.003%, with 0.20-0.6% manganese.
- 4 Magnesium anodes are not suitable for long term protection in sea water.

TABLE 2.2
CHEMICAL COMPOSITION LIMITS FOR ZINC ALLOY ANODES

Element	Chemical composition, %			
	Z1* Min.	Z1* Max.	Z2 Min.	Z2 Max.
Cadmium	0.025	0.07	—	0.003
Aluminium	0.10	0.50	—	0.005
Silicon	—	0.005	—	0.003
Copper	—	0.005	—	0.003
Iron	—	0.005	—	0.0014
Lead	—	0.006	—	0.003
Other impurities				
—each	—	0.005	—	0.005
—total	—	0.02	—	0.02
Zinc	remainder		remainder	

* Corresponds to MIL-A-18001k alloy composition.

NOTE: Typical uses for these alloys are given in Paragraph B3.2.