

Australian Standard[®]

Cathodic protection of metals

Part 4: Internal surfaces



This Australian Standard® was prepared by Committee MT-014, Corrosion of Metals. It was approved on behalf of the Council of Standards Australia on 29 September 2006. This Standard was published on 23 October 2006.

The following are represented on Committee MT-014:

- AUSTAP
 - Australian Corrosion Association
 - Australasian Institute of Metal Finishing
 - Australian Chamber of Commerce and Industry
 - Australian Electrolysis Committee
 - Australian Paint Manufacturer's Federation
 - Australian Paint Approval Scheme
 - Australian Pipeline Industry Association
 - Blast Cleaning and Coating Association of Australia
 - Bureau of Steel Manufacturers of Australia
 - Division of Building, Construction and Engineering, CSIRO
 - Energy Networks Association
 - Galvanizers Association of Australia
 - United Water International
 - Water Corporation of Western Australia
 - Corrosion consultants
 - Water Services Association of Australia (WSAA)
-

This Standard was issued in draft form for comment as DR 06282.

Standards Australia wishes to acknowledge the participation of the expert individuals that contributed to the development of this Standard through their representation on the Committee and through public comment period.

Keeping Standards up-to-date

Australian Standards® are living documents that reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued.

Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments that may have been published since the Standard was published.

Detailed information about Australian Standards, drafts, amendments and new projects can be found by visiting **www.standards.org.au**

Standards Australia welcomes suggestions for improvements, and encourages readers to notify us immediately of any apparent inaccuracies or ambiguities. Contact us via email at **mail@standards.org.au**, or write to Standards Australia, GPO Box 476, Sydney, NSW 2001.

STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 2832.4—2006

**Cathodic protection of metals
Part 4: Internal surfaces**

RECONFIRMATION NOTICE

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.

Certain documents referenced in the publication may have been amended since the original date of publication. Users are advised to ensure that they are using the latest versions of such documents as appropriate, unless advised otherwise in this Reconfirmation Notice.

Approved for reconfirmation in accordance with Standards Australia procedures for reconfirmation on 14 July 2016.

The following are represented on Technical Committee MT-014:

Australasian Corrosion Association
Australasian Corrosion Association, NZ Branch
Australian Chamber of Commerce and Industry
Australian Electrolysis Committee
Australian Industry Group
Australian Paint Manufacturers' Federation
Australian Pipelines and Gas Association
AUSTROADS
Bureau of Steel Manufacturers of Australia
CSIRO
Galvanizers Association of Australia
Galvanizing Association of New Zealand
Materials Australia
New Zealand Abrasive Blasting Association
New Zealand Heavy Engineering Research Association
United Water International
Water Services Association of Australia

NOTES

Australian Standard[®]

Cathodic protection of metals

Part 4: Internal surfaces

Originated as AS 2832.4—1994.
Second edition 2006.

COPYRIGHT

© Standards Australia

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher.

Published by Standards Australia GPO Box 476, Sydney, NSW 2001, Australia

ISBN 0 7337 7801 1

PREFACE

This Standard has been prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-014, Corrosion of Metals, to supersede AS 2832.4—1994, *Cathodic protection of metals*, Part 4: *Internal surfaces*.

After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than an Australian/New Zealand Standard.

The objective of this revision is to revise the current cathodic protection requirements for the protection of internal surfaces.

This Standard is Part 4 of the AS 2832 series of Standards. The other parts are as follows:

AS

2832	Cathodic protection of metals
2832.1	Part 1: Pipes and cables
2832.2	Part 2: Compact buried structures
2832.3	Part 3: Fixed immersed structures
2832.4	Part 4: Internal surfaces (this Standard)
2832.5	Part 5: Steel in concrete structures

The Committee decided that there were no International Standards (ISO) which were suitable to be used as an Australian Standard.

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 information and guidance.

CONTENTS

	<i>Page</i>
FOREWORD.....	5
 SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	6
1.2 REFERENCED DOCUMENTS	7
1.3 DEFINITIONS	7
1.4 COMPETENCE OF PERSONNEL	11
 SECTION 2 CRITERIA FOR CATHODIC PROTECTION	
2.1 GENERAL	12
2.2 POTENTIAL CRITERIA FOR FERROUS VESSELS	13
2.3 POTENTIAL CRITERIA FOR MIXED METALLIC STRUCTURES.....	13
2.4 POTENTIAL CRITERIA FOR ALUMINIUM STRUCTURES	13
2.5 POTENTIAL CRITERIA FOR TITANIUM.....	13
2.6 OVERPROTECTION	13
 SECTION 3 MEASUREMENT AND EQUIPMENT	
3.1 GENERAL	14
3.2 POTENTIAL MEASUREMENT AND EQUIPMENT	14
 SECTION 4 DESIGN OF STRUCTURES FOR CATHODIC PROTECTION	
4.1 GENERAL	15
4.2 STRUCTURE COATING	15
4.3 INTERFERENCE WITH FOREIGN STRUCTURES	15
4.4 ISOLATION OF STRUCTURES IN CONTACT WITH THE INTERNAL ELECTROLYTE	16
4.5 ELECTRICAL CONTINUITY	16
4.6 FITTINGS TO SUPPORT ANODES AND MONITORING EQUIPMENT.....	16
4.7 VENTING	16
 SECTION 5 DESIGN OF CATHODIC PROTECTION SYSTEMS	
5.1 GENERAL	17
5.2 SAFETY PRECAUTIONS	17
5.3 DESIGN REQUIREMENTS	17
5.4 DESIGN DATA.....	18
5.5 CABLES.....	18
5.6 SYSTEM DESIGN DOCUMENTATION	20
 SECTION 6 INSTALLATION OF CATHODIC PROTECTION SYSTEMS	
6.1 GENERAL	21
6.2 MATERIALS AND EQUIPMENT ACCEPTANCE TESTS.....	21
6.3 INSTALLATION OF GALVANIC ANODE SYSTEMS	22
6.4 INSTALLATION OF IMPRESSED CURRENT SYSTEMS.....	22
6.5 REFERENCE ELECTRODES.....	23
6.6 SYSTEM DESIGN DOCUMENTATION	23
 SECTION 7 COMMISSIONING OF CATHODIC PROTECTION SYSTEMS	
7.1 SCOPE AND GENERAL	25
7.2 PRE-ENERGIZATION TESTING	25

7.3	SYSTEM OPERATION AND ADJUSTMENT.....	25
7.4	POST ENERGIZATION TESTS	26
7.5	RECORDS.....	26
7.6	COMMISSIONING REPORT	26
7.7	OPERATION MANUALS	27

SECTION 8 OPERATION AND MAINTENANCE OF CATHODIC PROTECTION SYSTEMS

8.1	GENERAL	28
8.2	MEASURING TECHNIQUES	28
8.3	CATHODIC PROTECTION POTENTIAL SURVEYS	28
8.4	EQUIPMENT MAINTENANCE CHECKS	29
8.5	STRUCTURE INSPECTIONS	30
8.6	RECORDS.....	30

APPENDICES

A	GUIDANCE ON THE GENERAL USE OF CATHODIC PROTECTION.....	31
B	MEASUREMENT OF STRUCTURE POTENTIALS USING THE OFF-POTENTIAL METHOD	34
C	COMPARISON OF STRUCTURE/ELECTROLYTE POTENTIALS OBTAINED WHEN MEASURED WITH VARIOUS REFERENCE ELECTRODES	36
D	GUIDANCE NOTES ON DESIGN OF CATHODIC PROTECTION SYSTEMS.....	39
E	COATINGS FOR USE WITH CATHODIC PROTECTION	47
F	INFORMATION FOR THE DESIGN OF STRUCTURES TO ACCOMMODATE PROTECTION	52
G	EXAMPLE OF CATHODIC PROTECTION SYSTEM DESIGN DOCUMENTATION FOR INTERNAL SURFACES	53
H	GRAPHICAL SYMBOLS RELATING TO CATHODIC PROTECTION	54
I	CALCULATION OF ELECTRIC FIELD STRENGTH NEAR AN IMMersed ANODE	55
J	EXAMPLE CALCULATION OF APPROPRIATE ANODE TO STRUCTURE SEPARATION	56
K	CALIBRATION AND MAINTENANCE OF REFERENCE ELECTRODES.....	58

FOREWORD

Corrosion of a metal is an electrochemical reaction between the metal and its environment which results in wastage of the metal. Thus corrosion is a combination of chemical effects with an associated flow of electrical energy (corrosion current).

In many practical situations where it is impossible to change the nature of the environment, corrosion may be prevented by employing cathodic protection. This is achieved by applying an appropriate direct current flowing in opposition to the original corrosion current, thus preventing the natural tendency of the metal to react with its environment. In practice, the electrical potential of the metal at risk is used to judge whether adequate protection is being achieved.

To employ cathodic protection, a circuit is established by connecting a suitable source of direct current to the structure to be protected.

Two types of cathodic protection systems are available as follows:

- (a) Galvanic anode systems, which employ metallic anodes that sacrifice themselves to provide the source of direct current for protection of the structure.
- (b) Impressed current systems, which employ an external electrical power source of direct current for the protection of the structure.

Corrosion control for a structure should be considered at the conceptual design stage. Factors which affect the corrosion of metallic structures are listed in Paragraph A3 of Appendix A. The practices recommended in this Standard relate to steps that need to be taken following a decision to apply cathodic protection to a structure. These steps are as follows:

- (i) Decide whether the structure should be coated. If the decision is to coat, then decide which particular coating system should be employed. If the structure is already installed, a determination should then be made of whether the nature and quality of the coating are compatible with cathodic protection.
- (ii) Design the structure to be compatible with cathodic protection and to include cathodic protection facilities during construction. If the structure is already installed, determine the measures to be taken to apply cathodic protection effectively, and the facilities necessary for cathodic protection monitoring.
- (iii) Design the cathodic protection system. If the structure is already installed, the design parameters may be measured and an optimum design provided. If the structure is not installed, a number of assumptions will be required for the estimation of design parameters.
- (iv) Install the cathodic protection system.
- (v) Commission the cathodic protection system after achieving a balance of cathodic protection current to enable the entire structure to be protected with minimum current, and with as uniform a potential over its surface as is practicable.
- (vi) Monitor cathodic protection at regular intervals, adjusting the conditions of operation as necessary, and maintain complete records of its operation.

STANDARDS AUSTRALIA

Australian Standard

Cathodic protection of metals

Part 4: Internal surfaces

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the cathodic protection of internal surfaces of pipes and structures including but not limited to heat exchangers, hot water systems, clarifiers, ballast and water storage tanks, cooling conduits and process plants. The internal surfaces of these vessels/structures may contain waters, seawaters, drinking water, brackish waters, sewage and brines. These applications will be termed electrolytes throughout the Standard.

The Standard specifically covers the following subjects which relate to cathodic protection:

- (a) The design of structures requiring cathodic protection.
- (b) Coatings for use on internal surfaces.
- (c) Criteria for the choice of cathodic protection potential.
- (d) The design of cathodic protection systems.
- (e) The installation of cathodic protection systems.
- (f) The operation and maintenance of cathodic protection systems.

NOTES:

- 1 Guidance on the general use and design of cathodic protection systems and factors affecting the corrosion of internal surfaces are given in Appendix A.
- 2 This Standard employs conventional (positive) current flow, for consistency with accepted practice, and uses the potential sign conventions specified in AS 1852. In order to understand the various electrochemical reactions which occur at electrodes during cathodic protection, it should be recognized that electron flow occurs in the opposite direction to conventional current flow.
- 3 For guidance on the use of coatings on the internal surfaces of structures which are to be cathodically protected, refer to Appendix E.
- 4 For guidance on the environmental factors which should be considered when designing a cathodic protection system, refer to Appendix F.
- 5 For an example of a form that may be used with designing a cathodic protection system of internal surfaces, refer to Appendix G.
- 6 For guidance on the graphical symbols relating to cathodic protection refer to Appendix H.
- 7 For guidance on the calibration and maintenance of reference electrodes, refer to Appendix K.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 1056 Storage water heaters (series)
- 1627 Metal finishing—Preparation and pretreatment of surfaces
- 1627.4 Part 4: Abrasive blast cleaning of steel
- 1852 International electrotechnical vocabulary (series)
- 2239 Galvanic (sacrificial) anodes for cathodic protection

AS/NZS

- 1768 Lightning protection
- 2053 Conduits and fittings for electrical installations (series)
- 3000 Electrical installations (known as the Australian/New Zealand Wiring Rules)
- 3100 Approval and test specification—General requirements for electrical equipment
- 4020 Testing of products for use in contact with drinking water
- 5000 Electric cables—Polymetric insulated
- 5000.1 Part 1: For working voltages up to and including 0.6/1 (1.2) kV
- 60479 Effects of current on human beings and livestock
- 60479.1 Part 1: General aspects
- 60479.2 Part 2: Special aspects
- 61558 Safety of power transformers, power supply units and similar
- 61558.1 Part 1: General requirements and tests

1.3 DEFINITIONS

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

1.3.1 Anaerobic

Lacking free oxygen.

1.3.2 Anode (in general)

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

1.3.3 Anode screen

A safety barrier surrounding a submerged anode for the prevention of electrical shock or shorting.

1.3.4 Anode shield

A protective covering of insulating material applied to a structure in the immediate vicinity of an anode in order to reduce local cathodic current density.

1.3.5 Back e.m.f.

An instantaneous open circuit opposing voltage between an anode and cathode of an operating cathodic protection system.

NOTE: Back e.m.f. may have other definitions in other technologies.

1.3.6 Backfill (anode)

Material surrounding, and in contact with, a buried anode for the purpose of maintaining or improving its performance.

1.3.7 Bond (coating)

Adhesion between the coating materials and the substrate.

1.3.8 Bond (drainage)

See 'Drainage (stray current)'.

1.3.9 Bond (electrical)

A metal connection between points on the same structure or on different structures.

1.3.10 Cathode

The electrode through which direct current leaves an electrolyte causing reduction reactions to take place.

1.3.11 Cathodic disbonding

Detachment of a coating due to the effect of cathodic polarization.

1.3.12 Cathodic protection

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

1.3.13 Cathodic protection unit

d.c. power supply controller for an impressed current, cathodic protection system.

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

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

1.3.15 Corrosion

The deterioration of metal caused by its electrochemical reaction with its environment.

1.3.16 Corrosion cell anode

The electrode at which metal dissolution (corrosion) takes place.

1.3.17 Current density (at anode)

Current output of anode divided by the anode surface area.

1.3.18 Current density (at cathode)

Current flowing into cathode divided by the cathode surface areas.

1.3.19 Current density (at coated cathode)

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

1.3.20 Corrosion current

The current flowing in a corrosion cell, electrochemically equivalent to the anode and cathode reactions.

1.3.21 Drainage (stray current)

An electrical means whereby stray current is removed from the structure via a conductor.

1.3.22 Earth (noun)

The conducting mass of the general body of the earth.

1.3.23 Earth (verb)

The act of connecting any conductor to earth.

1.3.24 Electrode

An electronic conductor that allows current to flow either to or from an electrolyte with which it is in contact.

1.3.25 Electrode potential

The measured potential of an electrode in an electrolyte relative to the potential of a reference electrode.

1.3.26 Electrolyte

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

1.3.27 Extra low voltage (ELV)

Voltage not exceeding 50 V a.c. or 120 V d.c. (max. 10% ripple, see AS/NZS 3000).

1.3.28 Ferrous metal structure

A structure comprising an iron-based alloy containing more than 50% iron.

1.3.29 Foreign (secondary) structure

A buried or submerged structure that may be subject to interference arising from the cathodic protection of a primary structure.

1.3.30 Galvanic action

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

1.3.31 Galvanic anode

An electrode used to protect a structure by galvanic action.

1.3.32 Ground-bed

A group of buried anodes.

1.3.33 Half-cell

See 'Reference electrode'.

1.3.34 Impressed current (IC)

Direct current supplied by an external power source to cathodically protect a structure.

1.3.35 Impressed current anode

The electrode connected to the positive terminal of an impressed current power supply.

1.3.36 Insulating joint

A joint which breaks electrical continuity in a structure, but does not affect the mechanical integrity.

1.3.37 Interference

A significant change in current density on a foreign structure caused by a cathodic protection system; it may be detected by a resultant potential change on the structure.

1.3.38 Interrupter

A timing device which permits a cyclic on/off interruption to the flow of cathodic protection current.

1.3.39 IR drop

See 'Resistance potential'.

1.3.40 Loop resistance

The total external circuit resistance at the output terminals of the cathodic protection impressed current rectifier.

1.3.41 Negative bonding grid

An electric network normally used for wharf and jetty structures cross bonding steel element requiring protection to form a common cathode.

1.3.42 Overprotection

The state that occurs when the cathodic polarization of a structure is at a level beyond that required for corrosion protection. Over protection may cause effects which are detrimental to the structure.

1.3.43 Polarization

A change in the potential of a corroding metal from its natural steady state value, as a result of current flow.

1.3.44 Polarization cell

An electrochemical device which, at potential levels typical of cathodically protected structures, has high impedance to direct current but low impedance to alternating current.

1.3.45 Polarized potential

The potential of a structure at the structure-to-soil interface. (This potential is thus free of voltage gradients that may accompany current flow through the electrolyte).

1.3.46 Primary structure

The structure which is subject to intentional cathodic protection.

1.3.47 Protective potential

The potential to which a metallic structure is reduced to achieve cathodic protection.

1.3.48 Protective current

The current made to flow into a metallic structure from its electrolytic environment, and which cathodically protects the structure.

1.3.49 Reference electrode

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

1.3.50 Remote earth

A location sufficiently distant from the structure and anode to be free from voltage gradients in the electrolyte.

1.3.51 Resistance potential

That part of a measured electrode potential attributable to the passage of current through the electrolyte resistance between cathode surface and reference electrode.

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

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

NOTE: These are used mainly with seawater.

1.3.53 Stray current

Current flowing through paths other than the intended circuit.

1.3.54 Structure

A metal surface in contact with an electrolyte.

1.3.55 Structure potential

The potential of a structure relative to that of a specified reference electrode situated in the electrolyte immediately adjacent to the structure.

1.3.56 Structure potential shift

A change in measured voltage of a metallic structure caused by the application of current from an external source.

1.3.57 Sulfate-reducing bacteria

A group of bacteria which is capable of reducing sulfate to sulfide in anaerobic, near-neutral soils and natural waters.

1.3.58 Test point

A nominated point on a structure for electrical contact.

1.3.59 Transformer/rectifier

A form of cathodic protection unit.

1.4 COMPETENCE OF PERSONNEL

The parties responsible for the design, survey, inspection, testing and maintenance of cathodic protection systems shall have the requisite experience and qualifications in cathodic protection.

The Australasian Corrosion Association provides training and accreditation for personnel in the corrosion prevention industry.

SECTION 2 CRITERIA FOR CATHODIC PROTECTION

2.1 GENERAL

Many metals are protected from corrosion by the application of direct current which maintains the potential sufficiently negative with respect to its environment to prevent corrosion. Direct current is provided by the use of galvanic anodes, or by means of an impressed current system. The potential of a structure with respect to its environment can give a reliable indication of the degree of protection being provided.

Potential criteria are applicable where the structure temperature is near ambient, and the electrolyte near the metal/electrolyte interface that are substantially free of active anaerobic bacteria. If these conditions are not met, an evaluation of the conditions should be carried out and an appropriate criterion determined.

The criteria given in Clauses 2.2, 2.3, 2.4, 2.5 and 2.6 apply provided that there is not a significant voltage gradient in the electrolyte between the structure and the reference electrode. A method of preventing the cathodic protection electrolyte voltage from affecting the measured potential readings is to measure an instantaneous off-potential. This procedure and its applicability are detailed in Appendix B.

The potential criteria to provide protection are given in Clauses 2.2 and 2.3, however other potential criteria may be used, provided that their efficacy has been established.

NOTE: It is important that sufficient tests be carried out to ensure that the entire structure conforms with the appropriate potential criterion.

This Standard recommends the use of copper/copper sulfate reference electrodes however these electrodes may not be suitable for some environments.

Reference electrodes such as silver/silver chloride, calomel, lead/lead chloride, metallic zinc, lead or steel, may be used as alternatives to copper/copper sulfate provided their relativity to this reference electrode in the environment has been established.

NOTES:

- 1 Where a silver/silver chloride reference electrode is of the type which has the central billet directly exposed to the electrolyte in which it is immersed, rather than being encapsulated in a chloride ion-rich electrolyte, the protection criteria will vary with the change in concentration of chloride ions present, requiring appropriate correction to the measured value. This type of silver/silver chloride reference electrode is used mainly in seawater where the chloride ion concentration is substantially constant.
- 2 Copper/copper sulfate reference electrodes should not be used in waters containing a high level of chloride as chloride diffusion into the electrode will affect its potential.
- 3 Electrolyte movement affects both oxygen access and also physical erosion of the corrosion film. With some metal/environment conditions, an increase in temperature may increase the corrosion activity, however this may reduce the oxygen availability. The interpretation of corrosion conditions requires significant expertise and is required prior to the application of cathodic protection.
- 4 A comparison of the structure/electrolyte potentials obtained using various reference electrodes is given in Appendix C.

2.2 POTENTIAL CRITERIA FOR FERROUS VESSELS

The accepted practices for the protection of internal surfaces of ferrous vessels, including vessels with fittings which are cathodic to steel, e.g. brass, copper and bronze fittings, are as follows:

- (a) The potential at all surfaces should be equal to, or more negative than, -850 mV with respect to a copper/copper sulfate reference electrode.
- (b) Where anaerobic bacteria are active the potential at all surfaces should be equal to, or more negative than, -950 mV with respect to a copper/copper sulfate reference electrode.
- (c) For environmental conditions which include low pH, elevated temperatures, aggressive chemicals, or a combination of these, the potential criteria may vary widely and need to be individually established for the system under consideration.

NOTE: Caution is also required as the potential of the reference electrode may vary due to the effects of these conditions refer Appendix C.

2.3 POTENTIAL CRITERIA FOR MIXED METALLIC STRUCTURES

The accepted practice for the protection of mixed metallic structures is to maintain a negative potential on all parts of the structure at least equal to that required for the most anodic metal between all structure surfaces and a copper/copper sulfate reference electrode.

2.4 POTENTIAL CRITERIA FOR ALUMINIUM STRUCTURES

The accepted practice for the protection of the immersed surface aluminium structure is to maintain a potential on all parts of the structure equal to, or more negative than, -900 mV with respect to a copper/copper sulfate reference electrode.

2.5 POTENTIAL CRITERIA FOR TITANIUM

The potential at all titanium surfaces should be in the range -520 mV to -820 mV with respect to copper/copper sulfate reference electrode.

NOTE: An example where the application of cathodic protection is applied to titanium is for tube, sheet and plates within condenser end boxes.

2.6 OVERPROTECTION

2.6.1 Ferrous structures

To ensure that overprotection does not cause accelerated disbondment of the coating, or other deleterious effects, a potential corrected for voltage gradient error should be measured. For coated structures, the polarized potential should not be more negative than -1.2 V with respect to a copper/copper sulfate reference electrode. Less negative values may be appropriate for coatings that are more susceptible to cathodic disbonding.

2.6.2 Aluminium structures

If the potential is more negative the -1050 mV , aluminium will be corroded by a build-up of alkalinity around the structure.

SECTION 3 MEASUREMENT AND EQUIPMENT

3.1 GENERAL

All instruments used for determining protection status shall be of an appropriate type and accuracy and shall have a valid calibration certificate. Calibration of the equipment shall be carried out to the required level of accuracy, annually, or at intervals appropriate to its stability, or whenever service conditions may have resulted in loss of accuracy. Care shall be taken to ensure that the correct polarity is noted in all measurements.

Records shall be maintained to keep information on instruments used to conduct specific tests and any subsequent calibration adjustments.

The polarity of the test cables shall be checked to ensure that the correct sign is applied to the potential values.

3.2 POTENTIAL MEASUREMENT AND EQUIPMENT

3.2.1 General

The equipment used for potential measurements shall have the following characteristics:

- (a) An input impedance of at least 10 M Ω , unless it can be verified that a lower impedance is adequate to contain errors to less than 10 mV at the point(s) being tested.
- (b) An accuracy of better than ± 10 mV.
- (c) a.c. rejection of better than 60 dB, together with an ability to reject overload by a.c. signals of up to 30 V r.m.s., unless it can be verified that lesser a.c. rejection characteristics are adequate at the point(s) being tested.

NOTES:

- 1 The half cell or reference electrode resistance may be assessed by shunting the voltmeter with a resistor of about one tenth of the input resistance of the meter. A variation of 10% or more between the unshunted and shunted voltmeter readings, indicates unsatisfactory reference electrode resistance conditions and corresponds to an error in the unshunted voltmeter reading of approximately 1%. Alternatively a voltmeter with a selectable input impedance may be used for assessing the acceptability of reference electrode electrolyte resistance.
- 2 In hazardous areas intrinsically safe equipment may be required.

3.2.2 Position of monitoring electrodes

When measuring potential, reference electrodes shall normally be placed at locations of minimum voltage gradients, remote from anode and as close as possible to the structure. Voltages in the measured potential due to IR drop shall be less than 10 mV, or shall be taken into account when determining potential readings. These considerations shall similarly apply when establishing the potential of fixed electrodes.

SECTION 4 DESIGN OF STRUCTURES FOR CATHODIC PROTECTION

4.1 GENERAL

This Section specifies requirements for the design of structures to accommodate the application of internal cathodic protection.

Because some aspects of the design and construction of the structures can interfere with the corrosion prevention process, cathodic protection should become an integral part of the design stage. This will tend to minimize unnecessary and possibly costly modifications, and help to ensure the safe operation of the structure and maximize its economic life.

The design of the internal surfaces to be protected shall be as open as possible, avoiding semi-enclosed compartments, deep recesses and shielded areas which may give rise to localized underprotection.

NOTE: Cathodic protection systems designed to provide protection to internal surfaces do not provide any protection to external surfaces of the structure. When protection to both internal and external surfaces is required, it is necessary to have separate cathodic protection systems.

4.2 STRUCTURE COATING

Cathodic protection may be applied to bare or coated surfaces. The following factors shall be considered when determining whether the surface is to be coated or remain bare:

- (a) The magnitude of the current required to achieve protection. This current is considerably less for coated surfaces. When surfaces are coated the cathodic protection installation may be smaller and less complex than that which would be required to protect uncoated surfaces. Longer life will result from a similarly designed sacrificial cathodic protection system used to protect coated surfaces.
- (b) Uniformity of current distribution to an uncoated structure. This may be difficult to achieve, particularly if the structure contains deep recesses or shielded areas. Coating the structure may result in more uniform protective potentials.
- (c) The electrolyte resistivity shall be considered. The protective current will penetrate further into recesses and corners when the electrolyte resistance is low. If recesses are present and the electrolyte has high resistivity, coating is strongly recommended.
- (d) The ability to apply and maintain the coating.
- (e) Areas not continuously immersed in electrolyte shall be determined. These may receive only partial protection from a cathodic protection system. The degree of protection depends on many factors including electrolyte composition, the relative immersed and non-immersed periods, the tendency of the surface to dry out during non-immersed periods and the protective potential when immersed. Typical examples of variable immersion occur in ship ballast tanks and water supply storage tanks. Coatings shall be applied in these areas if maximum protection is required.

4.3 INTERFERENCE WITH FOREIGN STRUCTURES

Systems installed for the cathodic protection of internal surfaces generally do not cause stray current external to the protected structure. Therefore interference with foreign external structures is not a problem and special design considerations to mitigate interference are not necessary. For this reason, regulatory authorities do not generally require formal approval and registration of these internal cathodic protection systems.

4.4 ISOLATION OF STRUCTURES IN CONTACT WITH THE INTERNAL ELECTROLYTE

In most cases all of the immersed metallic areas in contact with the internal electrolytes will require protection. Electrical isolation from external structures will usually not be required.

Isolation of internal components may be desirable or necessary, e.g. a stainless steel ladder or the presence of a major area of non-ferrous metal will significantly increase the protective current requirement, if not isolated.

Immersed structures such as columns and pipework shall be electrically isolated from reinforcing systems. This isolation may be required at the top and the bottom of the column.

NOTES:

- 1 As interference corrosion is possible on electrically isolated components, consideration should be given to the means for its mitigation.
- 2 Electrical isolation may be achieved by the use of flange insulating assemblies, couplings, monolithic joints or custom-designed insulation.
- 3 Where highly conductive fluids such as seawater and brine are involved, special consideration will need to be given to current transfer and interference effects between all isolated parts of the structure.

4.5 ELECTRICAL CONTINUITY

It is important that all surfaces requiring protection are in reliable low resistance metallic contact. Slipring bonding facilities or similar are necessary if protection is to be applied to rotating components such as pump impellers or rotating arm clarifiers, except where galvanic anodes are directly connected to the rotating component.

4.6 FITTINGS TO SUPPORT ANODES AND MONITORING EQUIPMENT

Provision should be made at the time of structure design for anode support fittings. These may comprise brackets, through-the-wall sockets or flanges, or other custom-designed components. Consideration should also be given to providing access for anode inspection and replacement.

Potential monitoring facilities are also desirable. For structures where the interior is not readily accessible, facilities should be provided for the placement of a portable or a permanent reference electrode and may comprise reference electrode access ports. They may include the provision of cable support fittings and suitable hardware.

4.7 VENTING

With impressed current systems, chlorine, oxygen or both are generated at the anode. These gases may be wholly dissolved in the water, but in some cases may also form gas bubbles or enter a vapour space above the water. With galvanic or impressed current systems insoluble hydrogen gas may be generated at the structure surface. Depending on the structure geometry, the provision of venting for these gases may need to be considered.

SECTION 5 DESIGN OF CATHODIC PROTECTION SYSTEMS

5.1 GENERAL

This Section specifies requirements for the design of cathodic protection systems for internal surfaces.

The object is to design a cathodic protection system to meet the criteria specified in Section 2 and aim for uniform potentials over the entire surface of the structure. However, in practice, wide variations are acceptable.

NOTE: State/Territory cathodic protection regulations are not applicable to the cathodic protection of internal surfaces.

The relevant requirements of AS 2239, AS/NZS 3000, AS/NZS 3100, AS/NZS 61558.1 and AS/NZS 5000.1, are applicable for conductor current ratings and the protection of circuits and transformers.

5.2 SAFETY PRECAUTIONS

5.2.1 Personal electrical safety

For personnel safety, the open-circuit voltage of a cathodic protection power supply shall not exceed 50 V d.c. unless appropriate safety precautions have been taken.

The open-circuit voltage of a cathodic protection power supply shall not exceed extra-low voltage. Consideration shall be given to the following electrical hazards:

- (a) The effects of lightning, both on the protected structure and via the electricity distribution system (personnel protection aspects are specifically covered in AS/NZS 1768).
- (b) Electrical gradients resulting from impressed current systems occurring in water around fully and partially submerged anodes and in electrolytes adjacent to anode installations.

NOTE: Paralysis and respiratory failure may result if a person comes in contact with electric field strengths greater than 3 V/m in water (see AS/NZS 60479.1 and AS/NZS 60479.2). Should the design result in a possible electric field strength exceeding this value in waters located close to impressed current anodes, warnings should be given and access to such areas prevented by shielding or by other means.

5.2.2 Aquatic electrical safety

Where underwater diving inspection or maintenance is likely to be carried out signs shall be displayed indicating the presence of any immersed cables or anode support ropes which are not physically protected. These warning notices shall be displayed advising of the danger of electrical gradients near the anodes and the necessity to switch off the system prior to diving.

5.3 DESIGN REQUIREMENTS

NOTE: General guidance on design of cathodic protection systems for fixed immersed structures is provided in Appendix D.

The cathodic protection system for a structure shall be designed to provide full protection for the specific life of the system. In particular the system shall—

- (a) achieve a level of protection in accordance with the performance criteria and the protection criteria appropriate to the structure, see Table D3;
- (b) comply with all the relevant regulatory requirements;