

Australian Standard™

Cathodic protection of metals

Part 3: Fixed immersed structures



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The following are represented on Committee MT-014:

Australasian 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
Austroads
Bureau of Steel Manufacturers of Australia
Department of Defence
Division of Building, Construction and Engineering, CSIRO
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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 2832.3—2005

Cathodic protection of metals

Part 3: Fixed immersed structures

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.

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NOTES

Australian Standard™

Cathodic protection of metals

Part 3: Fixed immersed structures

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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 2832.3—1992, *Cathodic protection of metals, Part 3: Fixed immersed structures*.

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 Standard is to provide Regulatory Authorities and the Australian corrosion mitigation industry with requirements for the cathodic protection of fixed immersed structures, such as wharves and piling, in order to minimize corrosion rates.

The objective of this revision is to specify the new design requirements for designing cathodic protection systems for fixed immersed structures.

This Standard is Part 3 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

2832.4 Part 4: Internal surfaces

2832.5 Part 5: Steel in concrete structures

The Committee determined 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, where an ‘informative’ appendix is only for information and guidance.

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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. The natural tendency of the metal to react with its environment is prevented by the application of an appropriate direct current to the structure surface.

Two types of cathodic protection system are available:

- (a) Galvanic anode systems, which employ buried or immersed metallic anodes which 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. 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 what 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) If necessary, design the cathodic protection system to include provisions for the mitigation of stray current effects. If the structure is already installed, the design parameters may be measured and an optimum design provided for the mitigation of stray current effects. If the structure is not installed, a number of assumptions will be required for the estimation of design parameters, and an adequate design for the mitigation of stray current effects may not be possible to achieve.

During the cathodic protection design stage, consideration should be given to the possibility that interference with foreign structures in the area may occur. In some circumstances this interference may only be resolved by field testing subsequent to installation.

- (iv) Install the cathodic protection system.

NOTE: Legislation in some States requires that a permit be obtained prior to the installation of a 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. Equipment installed for the mitigation of stray current effects should be balanced for optimum performance.

Carry out interference testing and satisfy all parties involved that any interference problems have been resolved, giving attention to regulatory requirements (if any) of the State in which the system is installed.

- (vi) Monitor cathodic protection at regular intervals, adjusting the conditions of operation as necessary, and maintain complete records of its operation.

NOTE: Further literature, guidance and details of training courses on corrosion and its control can be obtained from the Australasian Corrosion Association web address www.corrosion.com.au.

STANDARDS AUSTRALIA

Australian Standard Cathodic protection of metals

Part 3: Fixed immersed structures

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the cathodic protection of external surfaces of fixed immersed structures, including offshore platforms, wharves, jetties, pontoons, sewage treatment plants, water treatment plants, lock gates, dam gates, pump station piles in rivers, weirs, mooring buoys, piling, foundations and water inlet/outlet structures.

Whilst fixed immersed structures are rarely affected by stray direct traction currents, there are some significant examples where this does occur and where mitigation is required. Examples of affected fixed immersed structures are underwater tunnels and electrically continuous sheet piling along water-ways and harbours.

This Standard does not apply to steel in concrete structures, see AS 2832.5.

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 immersed metal structures.
- (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 control of interference currents on foreign structures.
- (g) The cathodic protection of structures subject to stray direct current.
- (h) The operation and maintenance of cathodic protection systems.

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 that occur at electrodes during cathodic protection, it should be recognized that electron flow occurs in the opposite direction to conventional current flow.

NOTES:

- 1 Guidance on the general use and design of cathodic protection systems and factors affecting the corrosion of immersed metallic structures are given in Appendix A.
- 2 This Standard employs positive current flow. The international convention is that the potential of an electrode is measured with respect to the potential of an electrode situated in the electrolyte. In the absence of cathodic protection, positive current in a corroding system flows through the electrolyte from the more negative to the more positive portion of the circuit. The aim of cathodic protection is to move the potential of the structure in the negative direction so that positive current flows on to it.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- 1627 Metal finishing—Preparation and pretreatment of surfaces
- 1627.2 Part 2: Power tool cleaning
- 1627.4 Part 4: Abrasive blast cleaning
- 1852 International electrotechnical vocabulary
- 2239 Galvanic (sacrificial) anodes for cathodic protection
- 2832 Cathodic protection of metals
- 2832.5 Part 5: Steel in concrete structures

AS/NZS

- 1020 The control of undesirable static electricity
- 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
- 5000 Electric cables—Polymetric insulated
- 5000.1 Part 1: For working voltages up to and including 0.6/1 (1.2) kV
- 60079 Electrical apparatus for explosive gas atmospheres
- 60079.10 Part 10: Classification of hazardous areas (IEC 60079-10:2002, MOD)
- 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 (series)

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 (electrical)

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

1.3.8 Bond (coating)

Adhesion between the coating materials and the substrate.

1.3.9 Bond (drainage)

See Drainage (stray current).

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 the movement of 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 unmeasured electrode potential attributable to the passage of current through the resistance between the cathode surface and the 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 sea water.

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.

NOTE: The Australasian Corrosion Association web address www.corrosion.com.au provides training and accreditation for personnel in the corrosion prevention industry.

SECTION 2 CRITERIA FOR CATHODIC PROTECTION

2.1 SCOPE AND GENERAL

2.1.1 Scope

This Section specifies the criteria for determining when the appropriate amount and distribution of direct current is being applied to the structure.

2.1.2 General

Metals may be protected from corrosion by the application of direct current to lower and maintain the potential of the metal sufficiently negative with respect to the environment. The direct current is provided by the use of an impressed current system, galvanic anodes, or a combination of both. The potential of a structure with respect to its environment can give a reliable indication of the degree of protection being provided.

The protection criteria are given in Clause 2.2. These criteria are with reference to either a copper/copper sulphate electrode or a silver/silver chloride electrode. This latter electrode is commonly used in marine and brackish water conditions, whereas the former is used on land and in fresh water. Either electrode can be used in both situations; however, the copper/copper sulphate electrode can become rapidly contaminated by chloride ions, whereas the silver/silver chloride electrode gives differing readings, depending on the concentration of the chloride in the environment. For measuring the potential of a structure using the off-potential method refer to Appendix B.

NOTE: 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 mainly used in sea water where the chloride ion concentration is substantially constant, see Appendix C.

Other reference electrodes may be used as alternatives to copper/copper sulfate and silver/silver chloride, provided that their relativity to these reference electrodes has been established.

NOTE: Criteria other than those listed may be used, if their efficacy has been established, see Appendix H.

2.2 PROTECTION CRITERIA

2.2.1 General

Protection criteria are with reference to either a copper/copper sulfate electrode or a silver/silver chloride electrode. This latter electrode is commonly used in marine conditions, whereas the former is normally used on land and in fresh water conditions. The copper/copper sulfate electrode can become rapidly contaminated by chloride ions.

2.2.2 Ferrous structures

The accepted practices for the protection of ferrous structures are as follows:

(a) *For structures submerged in sea water*

The criterion for protection of a ferrous structure immersed in sea water is to maintain a potential on all parts of the structure equal to, or more negative than, -800 mV with respect to a silver/silver chloride/sea water reference electrode.

NOTE: This potential is equivalent to -850 mV with respect to a copper/copper sulfate reference electrode.

(b) *For structures submerged in other waters (including drinking water)*

The criterion for protection of a ferrous structure immersed in waters other than sea water (including potable waters) is to maintain a potential on all parts of the structure equal to, or more negative than, -850 mV with respect to a copper/copper sulfate reference electrode.

NOTE: Where sulfate-reducing bacteria are active, a more negative potential may be required for protection.

2.2.3 Aluminium structures

The accepted practice for the protection of a submerged aluminium structure is to maintain a potential on all parts of the structure equal to, or more negative than, -900 mV, but not more negative than -1050 mV with respect to a copper/copper sulfate reference electrode.

2.2.4 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.

2.2.5 Structures subject to variable stray current effects

Variable stray traction and telluric current shall be evaluated when there is an indication that the structure potentials are varying, and shall be evaluated by carrying out a data-logger or chart recording of potentials in accordance with this Clause. It is very rare to encounter telluric effects on fixed immersed structures. If encountered, the same criteria shall be applicable.

The response of a structure to stray current excursions is dependent upon many factors including electrolyte resistivity, degree of aeration and structure coating quality, if any. The magnitude of the stray current excursions will also be dependent on the proximity of the source. The extent of a depolarization is determined by the frequency, magnitude and the duration of anodic excursions.

The measured potential is the sum of the polarized structure potential and the potential from the voltage gradient in the electrolyte. When potentials are affected by stray currents, it may not be possible to determine whether they are free of voltage gradients, and thus to compare the measured potential with the protection criterion. In such cases, an estimation of the electrolyte voltage gradient will suffice to determine compliance with the protection criterion.

NOTE: Refer to Appendix C for guidance on the calibration and maintenance of reference electrodes and Appendix E for the frequency of inspection for structures.

Where structures are required to be evaluated for stray traction current effects, it is necessary to record the potential during a sufficient period of time to ensure that the maximum exposure to the stray current effects is encompassed. This period shall include the morning and evening usage peaks and is nominally twenty hours. If a data-logger is used for the monitoring of potential, its frequency of sampling shall be not less than four samples per minute.

The protection criteria for structures subject to traction current effects varies with the structure polarization time as follows:

(a) *Structures with short polarization times*

Structures in high resistivity waters, or with sound coating characteristics in any electrolyte, shall comply with the following criteria:

- (i) The potential shall not be more positive than the protection criterion for more than 5% of the test period.

NOTE: With respect to copper/copper sulfate reference electrode.

- (ii) The potential shall not be more positive than the protection criterion plus 50 mV, i.e. –800 mV for ferrous structures, for more than 2% of the test period.

NOTE: With respect to copper/copper sulfate reference electrode.

- (iii) The potential shall not be more positive than the protection criterion plus 100 mV, i.e. –750 mV for ferrous structures, for more than 1% of the test period.

NOTE: With respect to copper/copper sulfate reference electrode.

- (iv) The potential shall not be more positive than the protective criteria plus 850 mV, i.e. 0 mV for ferrous structures for more than 0.2% of the test period.

NOTE: With respect to copper/copper sulfate reference electrode.

(b) *Structures with long polarization times*

Structures in a marine environment, or which have otherwise been proven to polarize and depolarize slowly in response to stray current, shall not be more positive than the protection criterion for more than 10% of the test period.

When assessing telluric current effects, it is important to correlate the degree of the ionospheric disturbance at the time of the recording. This may require recordings over an extended time period, i.e. several days.

2.3 OVERPROTECTION

2.3.1 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.

2.3.2 Aluminium structures

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

2.3.3 Potential criteria for titanium

The potential at all titanium surfaces should be in the range –520 mV to –820 mV.

NOTES:

- 1 With respect to copper/copper sulfate reference electrode.
- 2 An example where the application of cathodic protection is applied to titanium is for tube, sheet and plates within condenser end boxes.

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 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 contact 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. Voltage gradients shall be less than 10 mV when electrodes are in the vicinity of impressed current anodes and sacrificial galvanic anodes, or 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 SCOPE AND GENERAL

4.1.1 Scope

This Section provides requirements for the design of fixed-immersed structures to accommodate cathodic protection.

NOTES:

- 1 Information on the design of structures to accommodate cathodic protection systems can be found in Appendices D and E.
- 2 Guidance on coatings for the use with cathodic protection systems can be found in Appendix K.

For protection to be achieved, a structure should—

- (a) be immersed or buried in an electrolyte;
- (b) be electrically continuous; and
- (c) be electrically isolated from structures not requiring protection, where practical.

4.1.2 General

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

The design of a fixed immersed structure should be as simple as possible, avoiding complex shapes with sharp crevices and shielded or screened areas that may give rise to areas of localized under-protection.

Typical provisions for cathodic protection installation include the following:

- (a) Cable conduits and blockouts in concrete.
- (b) Steel conduits and fittings welded to the structure during the building stage.
- (c) Structure bonding.
NOTE: Inter-pile bonding is especially important for wharves and bridges. The piles should be bonded with a material which has an electrical resistance suitable for the cathodic protection system. Welded reinforcing bar is frequently used for this bonding.
- (d) Cable connection facilities to the bonded structure for both current carrying and monitoring facilities.
- (e) Foreign structure, e.g. ship to shore bonding facilities, see Section 8.

Careful consideration shall be given to the proposed materials to be used in a structure that is to be protected by cathodic protection.

Cathodic protection should be applied with caution to structures that are made from materials which are subject to attack under alkaline conditions (e.g. aluminium), due to the high pH levels developed at the cathode surface.

The effects of dissimilar metals and alloys on the structure shall be considered, in order to mitigate unintended bi-metallic corrosion and to select an appropriate protection criterion that recognizes the interaction that can occur between different metals.

4.2 STRUCTURE COATING

Structures shall always be coated in areas where cathodic protection is not effective, e.g. in and above the intermittently wetted or splash zone area of the structure. The remainder of the structure may be either coated or bare.

The following factors require consideration when determining whether a structure situated below water level shall be coated:

- (a) The geometry of the structure, and the presence of shielded areas.
- (b) The magnitude of the current demand required to achieve protection; the coating will reduce the current requirement and thus reduce the mass of any galvanic anode system installed.
- (c) The proximity of foreign structures; the coating will reduce the total applied current and thus reduce any interference caused to foreign structures.
- (d) The ability to maintain the coating on the structure.

4.3 TEST POINTS

Fixed testing points shall be established on the structure to monitor the effectiveness of the cathodic protection. The use of in-situ reference electrodes in association with various test points enable potentials to be measured in particular areas remote from the test points. Examples of such areas are:

- (a) Remote and shielded areas of the structure where the least protection potentials are likely to occur. In the case of platforms or jetties these points are likely to be in the throats of nodal joints. Such a reference can establish a correlation between normally measured potentials and the least protection potential.
- (b) Close to anodes to ensure that maximum polarization will not cause rapid cathodic disbonding of any coating system.
- (c) Surfaces which are warmer that may have different cathodic protection requirements than the remainder of the structure, e.g. hot riser pipes on oil platforms.

4.4 ISOLATION OF STRUCTURE

Isolation and/or surge protection devices may be used to isolate other structures to facilitate the use and control of cathodic protection systems. They may consist of flange assemblies, couplings, monolithic joints or custom-designed insulation. The dielectric strength of such devices shall be suitable for the selected purpose.

The mechanical design for isolation and/or surge protection devices shall comply with the requirements of the appropriate design code.

Typical points where provision of isolation and/or surge protection devices may be considered include the following:

- (a) Pipeline risers.
- (b) Connections to shore-based metallic structures.
- (c) Connections to earthed structures.
- (d) Connections to other cathodically protected structures.

Where isolation and/or surge protection devices are installed, any gap between metal surfaces shall be filled with an electrically insulating compound and the outer faces coated.

All monolithic joints shall be electrically tested prior to installation.

NOTE: Where monolithic joints or flanges are used in water pipes or oil pipes left standing and containing water, special precautions are necessary to prevent internal corrosion.

To facilitate the application and control of the cathodic protection system, it is recommended that the primary structure be isolated from any other electrically connected metallic structures. It may be impractical to isolate certain systems, e.g. wharf or material handling gantries. In such situations, the cathodic protection system should be designed to cope with the additional load.

If the superstructure shares a common a.c. power or static electrical earthing system with shore-based structures, problems may be avoided by isolating items of electrical equipment from the superstructure, and earthing these directly to the shore-based system without contact with the superstructure, or by using polarization devices or isolating transformers (see also Clause 5.2 for safety design precautions).

The cathodic protection current consumed by onshore foreign structures in electrical contact with cathodically protected offshore immersed structures is usually low if the offshore structure is immersed in low resistivity water, e.g. sea water, and the onshore structure is buried in relatively high resistivity soil.

If the immersed structure is in electrical contact with onshore structures, the relative consumption of cathodic protection current should be considered in the system design. If it is electrically isolated from onshore structures which are in close proximity to the cathodic protection system, testing is required to determine the magnitude of any interference to the onshore structure, and appropriate measures then taken to mitigate that interference (see Clause 5.4).

4.5 ELECTRICAL CONTINUITY

For cathodic protection to be effective, it is necessary to ensure that the structure, or each section of the structure, is electrically continuous. Bonds may be required to provide continuity to isolated sections, e.g. across bolted connections, sheet piling where the degree of metallic contact is uncertain, and in tubular and fender piling.

The design of the bond shall be sufficient to withstand installation and maintenance procedures. Bonds are required to carry the full current and to have low electrical resistances in accordance with the cathodic protection circuit design parameters.

SECTION 5 DESIGN OF CATHODIC PROTECTION SYSTEMS

5.1 GENERAL

This Section provides requirements for the design of cathodic protection systems for fixed immersed structures.

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: In addition to the recommendations of this Standard, compliance with the Regulations for applying the statutes and ordinances of State and local governments is necessary. Also the requirements of AS 2239, AS/NZS 3000, AS/NZS 3100, AS/NZS 61558 series and AS/NZS 5000.1 are applicable in respect of conductor current ratings and the protection of circuits and transformers.

5.2 SAFETY PRECAUTIONS

5.2.1 Personal electrical safety

For personal electrical safety the provisions of AS/NZS 3000 (the Wiring Rules) and AS/NZS 3100 (the application code) shall be adhered to.

Unless appropriate safety precautions have been taken the open-circuit voltage of a cathodic protection power supply shall not exceed extra-low voltage.

The following requirements shall also apply.

- (a) Because of the highly exposed nature of the anode/cathode circuits, in highly conductive wet environments, the open circuit power supply voltage of an impressed current system shall not exceed 50 V d.c. unless appropriate precautions have been taken.
- (b) Full consideration shall be given to surge effects due to power system components failure including voltage developed across insulated joints.
- (c) Consideration shall be given to the effects of lightning.

In addition, the following aspects shall be considered:

- (i) The effects of electric sparks on structures carrying products that are flammable and capable of forming explosive air/gas mixtures (see AS/NZS 60079.10). It is also necessary in such circumstances to ensure control of static electricity (see AS/NZS 1020).

NOTES:

- 1 AS/NZS 60079.10 defines the extent of hazardous zones in relation to various types of installations or items of equipment handling flammable liquids or gases. Protective devices should be installed to prevent build-up of static charge so that sparking does not occur.
- 2 Conduit or ducting proceeding from a cathodic protection installation into hazardous areas, e.g. test boxes and transfer enclosures, should be sealed to prevent the flow of flammable substances.