

Australian Standard[®]

Cathodic protection of metals

Part 5: Steel in concrete structures



This Australian Standard® was prepared by Committee MT-014, Corrosion of metals. It was approved on behalf of the Council of Standards Australia on 1 August 2008. This Standard was published on 17 September 2008.

The following are represented on Committee MT-014:

- Australasian Corrosion Association
 - Australian Chamber of Commerce and Industry
 - Australian Electrolysis Committee
 - Australian Paint Approval Scheme
 - Australian Pipeline Industry Association
 - AUSTROADS
 - Blast Cleaning and Coating Association of Australia
 - Bureau of Steel Manufacturers of Australia
 - Corrosion Prevention Centre
 - CSIRO Manufacturing and Materials Technology
 - Galvanizers Association of Australia
 - Materials Australia
 - Plumbing Products Industry Group
 - Water Services Association of Australia
 - Water Utility Interests
-

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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 the public comment period.

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STANDARDS AUSTRALIA

RECONFIRMATION

OF

AS 2832.5–2008

Cathodic protection of metals

Part 5: Steel in concrete 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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Bureau of Steel Manufacturers of Australia
CSIRO
Energy Safe Victoria
Galvanizers Association of Australia
Galvanizing Association of New Zealand
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Plumbing Products Industry Group
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NOTES

Australian Standard[®]

Cathodic protection of metals

Part 5: Steel in concrete 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 2832.5—2002, *Cathodic protection of metals, Part 5: Steel in concrete 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 specify requirements for the cathodic protection of reinforcing steel in concrete that is exposed either to atmospheric, submerged or buried environments with the aim of preventing or controlling corrosion to an acceptable level.

The objective of this revision is to update requirements in line with current industry practice, and to restructure the Standard to align with the AS 2832 series. Requirements for the qualifications of personnel have been added in the new Appendix E.

In preparation of this Standard, cognisance was taken of the European Standard EN 12696, *Cathodic protection of steel in concrete*.

This Standard is Part 5 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
2832.5	Part 5: Steel in concrete structures (this Standard)

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.

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FOREWORD

Cathodic protection is a technique that has been demonstrated to be successful, in appropriate applications, in providing cost effective long term corrosion control for steel in concrete. It is a technique that requires specific design calculations and definition of installation procedures in order to be successfully implemented.

A long term commitment to an active monitoring and inspection program is essential for continued success. This Standard is a performance Standard rather than a design code but requires a detailed design and a specification for the installation, commissioning and operation of a cathodic protection system, prepared by an appropriate specialist. The design may be undertaken by an independent consultant prior to the implementation of a contract for the installation of the system; the specialist may be part of the installation contractor's team. The design may be incorporated into the same contract as that for the installation of the cathodic protection system and, possibly, for subsequent commissioning and operation.

Other electrochemical treatments that provide corrosion control for steel in concrete, including electrochemical re-alkalization and electrochemical chloride extraction, are not covered by this Standard.

STANDARDS AUSTRALIA

Australian Standard
Cathodic protection of metals

Part 5: Steel in concrete structures

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE

This Standard specifies requirements for the cathodic protection of steel in atmospherically-exposed, buried and submerged concrete in both new and existing structures. It covers the parts of buildings and civil engineering structures that include normal reinforcement and prestressed reinforcement embedded in the concrete.

NOTE: Guidance on the principles of cathodic protection and its application to steel in concrete is given in Appendix A.

1.2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

AS

- | | |
|------------|---|
| 1012 | Methods of testing concrete |
| 1012.20 | Method 20: Determination of chloride and sulfate in hardened concrete and concrete aggregates |
| 1580 | Paints and related materials—Methods of test |
| 1580.108.2 | Method 108.2: Dry film thickness—Paint inspection gauge |
| 1580.408.5 | Method 408.5: Adhesion—Pull-off test |
| 2239 | Galvanic (sacrificial) anodes for cathodic protection |
| 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 |
| 5000 | Electric cables—Polymeric insulated |
| 5000.1 | Part 1: For working voltages up to and including 0.6/1 (1.2) kV |
| 60529 | Degrees of protection provided by enclosures (IP Code) |
| 61558 | Safety of power transformers, power supply units and similar |
| 61558.1 | Part 1: General requirements and tests |
| 61558.2.6 | Part 2.6: Particular requirements for safety isolating transformers for general use (IEC 61558-2-6:1997, MOD) |
| HB 79 | Alkali aggregate reaction—Guidelines on minimizing the risk of damage to concrete structures in Australia |
| HB 84 | Guide to concrete repair and protection |
| AS/NZS | |
| 1768 | Lightning protection |
| 3000 | Electrical installations (known as the Australian/New Zealand Wiring Rules) |

AS/NZS ISO

9001 Quality management systems—Requirements

ASTM

D4414 Standard practice for measurement of wet film thickness by notch gauges

EN

1504 Products and systems for the protection and repair of concrete structures—
Definitions, requirements, quality control and evaluation of conformity (series)

NOTE: A bibliography of other documents relating to this Standard is contained in Appendix F.

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 current density probe

An isolated portion of anode material permitting the measurement of anode current density.

1.3.4 Anode screen

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

1.3.5 Anode shield

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

1.3.6 Anodic polarization

Polarization towards anodic (more positive) potentials.

1.3.7 Atmospheric zone

Those parts of a concrete structure that are continuously exposed to the atmosphere.

1.3.8 Back e.m.f.

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

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

1.3.9 Backfill (anode)

The material surrounding, and in contact with, a buried or concrete embedded anode for the purpose of maintaining or improving the performance of the anode.

1.3.10 Base (native) potential

The natural steady state electrode potential (the corrosion potential), measured before polarization at an embedded reference electrode, during commissioning.

1.3.11 Bond (coating)

Adhesion between the coating materials and the substrate.

1.3.12 Bond (drainage)

(See drainage (stray current).)

1.3.13 Bond (electrical)

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

1.3.14 Buried zone

The parts of a structure that are permanently buried.

1.3.15 Cathode

The structure that is to be protected by cathodic protection.

1.3.16 Cathodic disbonding

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

1.3.17 Cathodic polarization

Polarization towards cathodic (more negative) potentials.

1.3.18 Cathodic protection

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

1.3.19 Cathodic protection unit

Direct current (DC) power supply controller for an impressed current, cathodic protection system.

NOTE: This includes transformers, rectifiers, solid state converters and direct current input from batteries, thermo-electric generators, closed circuit vapour turbines and other sources of direct current.

1.3.20 Commissioning

The set of procedures, tests and measurements that are undertaken following the installation of a cathodic protection system to ensure that the system is functioning satisfactorily, is providing full protection to the whole of the structure, and achieves the specified protection criteria within a defined commissioning period.

1.3.21 Constant current control

Automatic adjustment of the output of a transformer/rectifier to provide constant output current.

1.3.22 Constant potential control

Automatic adjustment of the output current and voltage of a transformer/rectifier so that the potential of the reinforcing steel, as measured by a fixed (embedded) reference electrode, is constant.

1.3.23 Constant voltage control

Automatic adjustment of the output of a transformer/rectifier to provide constant output voltage.

1.3.24 Converter

A device that converts electrical energy to extra low voltage (ELV) direct current.

NOTE: A rectifier is considered to be a converter.

1.3.25 Copper_{sat}copper sulfate (Cu/CuSO₄) reference electrode

A reference electrode consisting of copper in a saturated solution of copper sulfate. Also written as Cu/CuSO₄(sat) or abbreviated as CSE.

1.3.26 Corrosion

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

1.3.27 Corrosion cell anode

The electrode at which metal dissolution (corrosion) takes place or at which a net oxidation process occurs.

1.3.28 Corrosion cell cathode

The electrode at which a net reduction reaction (e.g. oxygen reduction) takes place.

1.3.29 Corrosion current

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

1.3.30 Coupon

A section of metal of similar size to a coating defect, used to monitor the corrosion of a coated structure that is subjected to cathodic protection (see resistance probe).

1.3.31 Current density (at anode)

The current output of the anode divided by the anode surface area.

1.3.32 Current density (at cathode)

The amount of current flowing into the cathode divided by the cathode surface area.

1.3.33 Current density probe

An electrode used to estimate the current density flowing to an area of reinforcing steel.

1.3.34 Depolarization/polarization decay/potential decay

The change in electrode potential with time, resulting from the interruption of the applied current.

1.3.35 Drainage (stray current)

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

1.3.36 Earth (noun)

The conducting mass of the general body of the earth.

1.3.37 Earth (verb)

To connect any conductor to earth.

1.3.38 Electrode

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

1.3.39 Electrode potential

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

1.3.40 Electrolyte

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

1.3.41 Embedded reference electrode

A reference electrode which is permanently fixed within the concrete structure close to, but not touching, the reinforcing steel.

1.3.42 Energizing

The process of the initial application of power to an impressed current cathodic protection system.

1.3.43 Extra low voltage (ELV)

Voltage not exceeding 50 V a.c. or 125 V d.c. (r.m.s.).

1.3.44 Ferrous metal structure

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

1.3.45 Foreign (secondary) structure

A buried or submerged structure, or metallic components in contact with the concrete, that may be subject to interference arising from the cathodic protection of a primary structure.

1.3.46 Galvanic action

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

1.3.47 Galvanic anode

An electrode used to protect a structure by galvanic action.

1.3.48 Galvanic isolator (polarization cell)

Device installed in series with the a.c. protective earthing conductor to block low-voltage d.c. galvanic current flow, but permit the passage of alternating current normally associated with the protective earthing conductor.

1.3.49 Ground-bed

A group of buried anodes.

1.3.50 Half-cell

(See reference electrode.)

1.3.51 Impressed current

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

1.3.52 Impressed current anode

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

1.3.53 Instantaneous off-potential

The electrode potential taken immediately after complete disruption of d.c. power (either impressed current or galvanic) to the system. The instantaneous off-potential is used as a close estimate of the IR drop-free polarized potential when there was current flow.

1.3.54 Interference

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

1.3.55 Interrupter

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

1.3.56 IR drop

(See resistance potential.)

1.3.57 Loop resistance

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

1.3.58 Luggin probe

An insulating tube filled with an electrolyte, terminating close to the metal surface under study, used to provide an ionically conducting path that is free of any significant potential variation along its length so that there is minimal diffusion between the reference electrode and the surface under study.

1.3.59 Macro-cell probe

A section of reinforcing steel embedded in chloride-enriched concrete or mortar, allowing measurement of the net current flowing to or from the probe.

1.3.60 Manganese/Manganese dioxide reference electrode (Mn/MnO₂)

An electrode of manganese/manganese dioxide with an alkaline chloride-free gel.

1.3.61 Mixed metal oxide

Generic name given to a variety of oxides (including oxides of iridium, ruthenium, titanium, tantalum and zirconium, and sometimes platinum) coated onto a titanium (or sometimes a niobium or a tantalum) substrate to act as an active surface for use as a cathodic protection anode.

1.3.62 On potential

The potential, including resistance potential, of a polarized structure.

1.3.63 Overprotection

The state that occurs when the cathodic polarization of a structure is at a level beyond that required for corrosion protection.

NOTE: Overprotection may cause effects that are detrimental to the structure.

1.3.64 pH

Defined as $-\log A_{H^+}$, where A_{H^+} is the activity of the hydrogen ion in solution.

1.3.65 Polarization

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

1.3.66 Polarized potential

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

1.3.67 Potential decay probe

An electrode (embedded in reinforced concrete) which is stable over a period of testing and used to measure the magnitude of depolarization rather than the reinforcement electrode potential.

1.3.68 Primary structure

The structure that is subject to intentional cathodic protection.

1.3.69 Protection criteria

The minimum specified protection requirements of a cathodic protection system.

1.3.70 Protection current density

The protection current divided by the cathode (reinforcing steel) surface area.

1.3.71 Protective current

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

1.3.72 Protective potential

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

1.3.73 Reference electrode

An electrode that 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.

1.3.74 Reinforcement

Steel bars, tendons, wires, conduits or structural sections embedded in concrete.

1.3.75 Reinforcement potential

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

1.3.76 Reinforcement potential shift

A change in the measured potential of reinforcement caused by the application of current from an external source.

1.3.77 Remote earth

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

1.3.78 Resistance potential

That part of a measured electrode potential attributable to the passage of current through the resistance between the cathode surface and a reference electrode. Also known as 'IR drop'.

1.3.79 Resistivity

The electrical resistance of a substance (e.g. concrete, soil, water) commonly expressed in ohm meters.

NOTE: Resistivity is also commonly expressed in industry in ohm centimetres.

1.3.80 Saturated calomel reference electrode (SCE)

An electrode consisting of mercury/mercurous chloride in contact with a saturated KCl solution.

1.3.81 Shielding

A reduction in cathodic protection current to a section of a protected structure due to obstruction by adjacent insulating materials.

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

An electrode consisting of silver, coated with silver chloride, in an electrolyte containing chloride ions. When written as Ag/AgCl/nMCl, this indicates that the MCl solution (M is a cation) has a molarity of n.

1.3.83 Splash zone

The parts of the concrete structure above high water level which are wetted by wave or splash action.

1.3.84 Sprayed concrete

Concrete which is placed by spraying by means of a pump and nozzle. Sprayed concrete is also known as 'shotcrete' and 'gunite'.

1.3.85 Standard hydrogen electrode (SHE)

An electrode comprising platinum black in a unit activity solution of hydrogen ions (1.05 M HCl saturated with hydrogen gas at 101 000 N/m² pressure). Defined as zero at any temperature and used as a base reference for all electrochemical reactions. Also referred to as a Normal Hydrogen Electrode (NHE).

1.3.86 Stray current

Current flowing through paths other than the intended circuit.

1.3.87 Submerged zone

The parts of the concrete structure that are permanently under water.

1.3.88 Test point

A nominated point on a structure for electrical contact or measurements.

1.3.89 Tidal zone

The parts of the concrete structure that are submerged or exposed according to changing water levels or tides.

1.3.90 Transformer/rectifier (T/R)

An electrical power unit which transforms and rectifies a.c. line voltages to the required d.c. output voltages, also referred to as a 'd.c. power supply'. (*See converter.*)

1.3.91 Zone

A discrete part of a cathodic protection system.

1.4 QUALITY MANAGEMENT SYSTEMS

The design, installation, energizing, commissioning and long-term operation of cathodic protection systems for steel in concrete shall be fully documented in accordance with AS/NZS ISO 9001.

Requirements for qualification of personnel are described in Appendix E.

Each element of the work shall be undertaken in accordance with a fully documented quality plan, which shall include the following requirements:

- (a) Each stage of the design shall be checked and documented.
- (b) Each stage of the installation, energizing, commissioning and operation shall be subject to appropriate visual, mechanical and/or electrical testing. The results of all testing shall be documented.

All test instrumentation shall have valid calibration certificates traceable to a national Standard of calibration.

The documentation shall constitute part of the permanent records for the works.

1.5 HEALTH AND SAFETY

All work associated with cathodic protection of steel in concrete shall comply with the relevant Commonwealth or State Occupational Health and Safety legislation.

1.6 PERSONNEL

All aspects of the cathodic protection system design, installation, testing of the installation, energizing, commissioning and long-term operational control shall be under the supervision of personnel who have appropriate training, expertise and experience in the areas of work they are responsible for.

Requirements for the qualifications of personnel are set out in Appendix E.

1.7 INDEPENDENT REVIEW OF DESIGN AND INSTALLATION

Where an independent review is required by the contract, this shall include (but not be limited) to the following items:

- (a) Confirm that the current densities and current requirements are appropriate for all cathodic protection zones.
- (b) Confirm that anode materials and anode operating levels are suitable for the intended purpose.
- (c) Confirm that reference electrodes, connections, cables, conduits, DC power supplies (where impressed current is used), and all other equipment are suitable and adequately rated.
- (d) Confirm that all drawings adequately reflect the proposed system and contain sufficient detail to enable correct installation of the system.
- (e) Confirm that all installation procedures are adequate.
- (f) Confirm that the inspection and testing methods are appropriate to ensure the system will be installed and perform as designed.
- (g) Confirm that the commissioning procedures are suitable to ensure the system can be energized and operated as designed.
- (h) Confirm that all aspects of the design, specification, drawings, installation, commissioning, records, documentation and operation conform to the requirements of this Standard and the requirements of the specification.

The independent reviewer shall be a person meeting the requirements set out in Appendix E.

An independent review is not always required, often depending on the scale of the project. The structure owner will normally stipulate whether an independent review is necessary.

SECTION 2 CRITERIA FOR CATHODIC PROTECTION

2.1 SCOPE

This Section gives information on criteria for determining when the appropriate amount and distribution of direct current are being applied to the concrete structure.

2.2 GENERAL

The overriding requirement providing for safe and effective operation of the cathodic protection system is that:

No instantaneous off steel/concrete potential shall be more negative than -1100 mV for plain reinforcing steel or more negative than -900 mV for prestressing steel with respect to Ag/AgCl/0.5M KCl.

The data collected in accordance with Clause 7.6 shall be reviewed and interpreted in respect to this requirement.

NOTES:

- 1 Prestressing steel can be sensitive to hydrogen embrittlement, which can cause catastrophic failure due to the high tensile loading of prestressing members. It is therefore essential that caution is exercised in any application of cathodic protection to prestressed elements.
- 2 This requirement is also aimed at safeguarding the steel/concrete bond in plain reinforced concrete structures.

2.3 CRITERIA

Initial and continuous adjustment of the cathodic protection system shall be based on meeting at least one of the following criteria which are listed in no priority order:

- (a) Potential decay criterion. A potential decay over a maximum of 24 h of at least 100 mV from the instantaneous off potential.
- (b) Extended potential decay criterion. A potential decay over a maximum of 72 h of at least 100 mV from the instantaneous off potential subject to a continuing decay and the use of reference electrodes (not potential decay sensors or pseudo reference electrodes) for the measurement extended beyond 24 h.
- (c) Absolute potential criterion. An instantaneous off potential (measured between 0.1 s and 1 s after switching the d.c. circuit open) more negative than -720 mV with respect to Ag/AgCl/0.5M KCl.
- (d) Absolute passive criterion. A fully depolarized potential, or a potential which is continuing to depolarize over a maximum of 72 h after the cathodic protection system has been switched off, which is consistently less negative than -150 mV with respect to Ag/AgCl/0.5M KCl.

Compliance with at least one of the above criteria shall be achieved within 6 months or alternatively, within a longer period as agreed with the structure's owner.

Compliance with at least one of the above criteria shall also be maintained on a continuous basis for the life of the system.

If any of the monitoring sensors do not confirm adequacy of protection, additional testing shall be undertaken to confirm that the rate of corrosion is insignificant.

NOTES:

- 1 The criteria given in Items (a), (b), (c) and (d) have been found to indicate adequate polarization which will lead to the maintenance or re-establishment of protective conditions for the steel within the concrete.
- 2 Compliance with the criteria given in Items (a), (b) and (d) may be invalidated if variations in temperature and moisture content, that can affect potential measurements, occur during the assessment period. It is necessary to quantify any such variations and take them into account when interpreting whether the protection criteria have been achieved.
- 3 Continuous monitoring, using data logging equipment, or by readings taken at least at one-hour intervals over a period of potential measurement of not less than 24 h, is recommended to ensure that environmental changes have not caused a significant change to potentials (see Note 4).
- 4 The criteria specified in this Clause rely on the accuracy and stability of the reference electrodes.
- 5 It may be appropriate in areas influenced by tidal effects or intermittent moisture exposure to curve fit logged data and extrapolate to a 24-hour period. This may be necessary in areas which are subject to concentration polarization (e.g. limiting rates of oxygen diffusion through water saturated capillary pores of the concrete) or re-polarization due to connection with submerged steelwork at more active potentials during the period of testing. Data should be logged at least at one minute intervals and the minimum time unaffected by the tidal movement or intermittent moisture effects should be 4 hours. Refer to Appendix A, Paragraph A3 for more information.

SECTION 3 ASSESSMENT AND REPAIR OF STRUCTURES

3.1 GENERAL

This Section outlines procedures for the assessment and repair of existing structures prior to the application of cathodic protection.

3.2 ASSESSMENT OF EXISTING STRUCTURES

3.2.1 Introduction

The assessment of a structure, including its material condition, its structural integrity and whether and how to repair it, shall be performed by competent personnel.

NOTE: Guidance for concrete repairs is given in HB 84.

The assessment of the structure shall include the following:

- (a) The nature, extent, location, severity and causes of damage and/or deterioration, and the ability of the structure to perform its function.
- (b) The likely remaining service life of the structure.
- (c) What is required to make the structure safe before and throughout any repair work, and for the required service life.

When cathodic protection is proposed as, or as part of, the repair/protection method for a structure, investigations shall include, but may not be limited to, those items in Clauses 3.2.2 to 3.2.10, in order to—

- (i) confirm suitability of cathodic protection;
- (ii) determine the extent of the cathodic protection system; and
- (iii) provide system design input information.

NOTE: In addition to these investigations, short or medium term small-scale trials may be performed to assess likely current demands for cathodic protection system design purposes.

3.2.2 Records

All available drawings, specifications, records, including photographic records, and notes shall be reviewed to assess the location, quantity, nature (e.g. uncoated, galvanized, epoxy-coated, and whether pre-stressed) and continuity of the reinforcement, and the constituents and quality of the concrete.

The available information shall be confirmed and supplemented by site survey and laboratory tests as specified in the following clauses.

3.2.3 Visual inspection

Where the structure is accessible, visual survey data shall be collected to assess the type, causes and extent of defects, and any features of the structure or its surrounding environment, which could influence the application and effectiveness of cathodic protection. For areas that have been previously repaired, the repair methods and the materials used shall be investigated.

The cause of any deterioration which is not attributable to corroded reinforcement shall be determined. Where any signs of structural distress are evident, an assessment of both the load bearing capacity of the structure, and the need for temporary or permanent strengthening, shall be carried out by suitably qualified personnel.

All areas of the structure that may require cathodic protection shall be checked for delamination of the concrete cover.

Defects such as cracks, honeycombing or poor construction joints which could permit significant water penetration, and which could in turn impair the effectiveness of the cathodic protection, shall be recorded.

3.2.4 Chloride analysis

The chloride content of the concrete sample shall be determined, in accordance with AS 1012.20.

NOTE: When selecting the core or drill diameter, the maximum aggregate size should be taken into account. Sampling rates and sampling locations should be varied depending on the manner in which the chloride was introduced into the concrete, i.e. internally in the mix or externally during service, e.g. from sea-spray. Chloride and cement content can be determined by the methods described in relevant Standards; however, it should be noted that the results obtained may only be accurate to $\pm 20\%$.

3.2.5 Carbonation depth measurement

Distribution of carbonation depths shall be measured on freshly fractured concrete surfaces by spraying with aqueous phenolphthalein solution in accordance with an agreed to procedure.

NOTE: Sampling points should be included at areas with minimum concrete cover to reinforcing steel, or where the concrete appears porous or honeycombed.

3.2.6 Concrete cover

Concrete cover and reinforcement size and position measurements shall be carried out in order to assess comparative current flow through areas of high and low cover, and to identify dense regions of reinforcement which may require high current density. The degree of shielding of the reinforcement to be protected, by embedded metal meshes, metal fibres, plates or plastic sheets, non-conductive repair materials or other materials which could impair the efficiency of cathodic protection shall be assessed. The possibility of short circuits occurring between reinforcing steel and the anode shall also be assessed.

3.2.7 Alkali aggregate reaction assessment

If the concrete of the structure to be protected contains aggregates which may be sensitive to alkali, the risk of alkali aggregate reaction shall be considered.

NOTE: Guidelines on minimizing the risk of damage to concrete structures due to alkali aggregate reactions are given in HB 79. Refer also to Appendix A, Paragraph A6.

3.2.8 Reinforcement continuity

The drawings shall be checked for reinforcement continuity which shall then be verified on site by measuring the electrical resistance and the potential difference between bars in mutually remote locations across the structure.

Reinforcement continuity shall be checked at the structure assessment stage, in accordance with the method given in Clause 5.2, for the purpose of confirming cathodic protection feasibility and providing design information. This check shall include at least an assessment of the following items on a representative basis:

- (a) Continuity between elements of the structure within each zone of the cathodic protection system.
- (b) Continuity of reinforcement within elements of the structure.
- (c) Continuity of metallic items, other than reinforcement, to the reinforcement itself.

At the subsequent repair and installation stage, reinforcement continuity shall be further checked in accordance with the methods and extent required in Clause 5.2.