AS 1789—2003
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AS 1789

Australian Standard™

Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)

Standards Australia

This Australian Standard was prepared by Committee MT-009, Metal Finishing. It was approved on behalf of the Council of Standards Australia on 8 August 2003 and published on 11 September 2003.

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Australian Industry Group
Australian Institute of Metal Finishing
Australian Paint Manufacturers Association
Bureau of Steel Manufacturers of Australia
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RECONFIRMATION
OF
AS 1789—2003
Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)

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NOTES

Australian Standard™

Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)

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PREFACE

This Standard was prepared by the Australian members of the Joint Standards Australia/New Zealand Committee MT-009, Metal Finishing to supersede AS 1789—1984, *Electroplated coatings—Zinc on iron or steel* and AS 1791—1986, *Chromate conversion coatings—Zinc and cadmium.* After consultation with stakeholders in both countries, Standards Australia and Standards New Zealand decided to develop this Standard as an Australian Standard rather than as an Australian/New Zealand Standard.

The objective of this Standard is to specify requirements for the electroplating of zinc (electrogalvanizing) and for the application of supplementary chromate conversion coatings, on iron and steel articles by batch processing, as opposed to continuous processing. For this purpose the technical content of AS 1791, *Chromate conversion coatings—Zinc and cadmium,* has been incorporated into this revision of AS 1789. Notwithstanding, passivation systems other than chromate are permissible.

Some manufacturers which zinc-electroplate dedicated articles on a large scale, using specialized, purpose-built facilities, prefer to describe their products as having been electrogalvanized. Since the latter term is technically acceptable and is favoured by a significant section of the marketplace, it has been incorporated into this revision of the Standard as a valid alternative term to electroplated zinc.

The content of this Standard relates to electrodeposition of zinc by the batch process. For the continuous process, reference should be made to AS 4750, *Electrogalvanized (zinc) coatings on ferrous hollow and open sections.* Hollow and open sections are, in general, semi-finished products, rather than commodities for use without significant further working or fabrication, which this Standard (i.e. AS 1789) covers.

This Standard specifies a range of electroplated zinc coatings for the protection of iron and steel against corrosion under various service conditions. It is a modification of ISO 2081:1986, *Metallic coatings—Electroplated coatings of zinc on iron or steel* and incorporates parts of ISO 4520, *Chromate conversion coatings on electroplated zinc and cadmium coatings.*

It is essential that purchasers state the coating classification code when placing their zinc coating orders with electroplaters. Likewise, manufacturers are required to state the coating classification code, when offering zinc plated (electrogalvanized) commodities for sale on the open market.

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.

Statements expressed in mandatory terms in footnotes to tables are deemed to be requirements of this Standard.

CONTENTS

Page

FOREWORD 4
1 SCOPE 5
2 REFERENCE DOCUMENTS 5
3 DEFINITIONS 6
4 BASIS METAL 6
5 COATING SYSTEM 7
6 COATING CLASSIFICATION CODE 8
7 HEAT TREATMENT 9
8 ZINC WHISKER GROWTH 9
9 ZINC COATING REQUIREMENTS 9
10 TEST METHODS FOR ZINC COATINGS 10
11 CHROMATE CONVERSION COATINGS 10
12 REQUIREMENTS AND TESTS FOR CHROMATE CONVERSION COATINGS. 11
13 CONFORMANCE 11
14 IDENTIFICATION 11

APPENDICES
A INFORMATION TO BE SUPPLIED TO THE ELECTROPLATER 13
B FACTORS THAT AFFECT THE CORROSION OF ZINC COATED ARTICLES .. 14
C MAINTENANCE OF ZINC-PLATED ARTICLES 20
D PRETREATMENT OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT 21
E POST-COATING TREATMENTS OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT 24
F RENOVATION OF DAMAGED AREAS 28
G TEST METHODS FOR CHROMATE CONVERSION COATINGS ON ZINC COATINGS 29

FOREWORD

This Standard specifies requirements for a range of thicknesses of zinc coatings to be applied to ferrous articles as protection against corrosion, but does not specify the surface condition, nor other aspects, of the basis metal.

The thickness of the zinc coating to be applied to the ferrous articles should be chosen by the purchaser, or by the manufacturer if the articles are for sale as a general commodity, to provide sufficient corrosion protection for the expected or design life of the articles under the environmental conditions to which they are to be exposed.

Electroplated zinc coatings are normally chromate treated to retard the formation of corrosion products on surfaces exposed to corrosive atmospheres. The type of chromate coating to be applied should be appropriate for the expected exposure environment.

Since chromate conversion coatings give additional protection against corrosion, they may only be omitted at the specific request of the purchaser. Zinc-plated articles intended to be painted may require a specific treatment, such as phosphating, to provide good paint adhesion. Other passivation systems may be substituted by agreement between interested parties.

Zinc-plated items are subject to attack by certain organic materials that release reactive vapours, such as cardboard, wood and certain electrical insulating materials. Cognizance should be taken of this when items are packed, stored or transported.

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Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)

1 SCOPE

This Standard specifies requirements for electroplated zinc coatings (or electrogalvanized coatings, see Note 1) on iron and steel articles by the batch process, except for coatings applied to—

(a) sheet, strip or wire in the unfabricated form (see Note 2);

(b) threaded fasteners (see Note 3); and

(c) close-coiled springs.

The Standard also specifies supplementary coatings, specifically chromate and other passivation systems, and makes provision for optional organic/inorganic coatings. It includes requirements for heat treatment, both before and after electroplating.

Appendix A sets out information to be supplied by the purchaser to the electroplater, or electrogalvanizer.

NOTES:

1 The term 'electrogalvanize', as well as its derivatives, is a technically acceptable alternative to 'zinc electroplate', provided that it is not abbreviated to 'galvanize', since the latter is the traditional contraction for 'hot-dip galvanize'.

2 Electrogalvanized coatings for strip are covered by AS 4750, while those for wire are incorporated in AS/NZS 4534.

3 The coating thickness that can be applied to threaded components may be limited by dimensional requirements, including class or fit. For guidance, attention is drawn to AS 1897, which specifies the maximum thickness that can be applied to standard threads

4 Specifications for electroplated zinc alloys are beyond the scope of this Standard.

5 Appendix B provides general information on factors that affect the corrosion of zinc-coated articles with further information being provided in AS/NZS 2312.

6 Recommendations on maintenance and repair procedures for zinc-coated articles are given in Appendix C

2 REFERENCE DOCUMENTS

The following documents are referred to in this Standard:

AS

1627 Metal finishing—Preparation and pretreatment of surfaces
1627.0 Method 0: Method selection guide

1897 Electroplated coatings on threaded components (metric coarse series)

2331 Methods of test for metallic and related coatings
2331.1.1 Method 1.1: Local thickness tests—Micrographic examination of cross-sections
2331.1.2 Method 1.2: Local thickness tests —Coulometric method
2331.1.3 Method 1.3: Local thickness tests —Magnetic method
2331.2.1 Method 2.1: Tests for average coating mass per unit area or for thickness—Dissolution methods—Strip and weigh and analytical
2331.3.1 Method 3.1: Corrosion and related property tests—Neutral salt spray (NSS) test

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2331.3.8 Method 3.8: Corrosion and related property tests—Humidity test—24 h cycle, damp heat

2331.4.1 Method 4.1: Physical tests—Qualitative adhesion tests

2483 Metal finishing—Recommended sampling plans for the inspection and testing of coatings (ISO 4519:1980, MOD)

4291 Mechanical properties of fasteners made of carbon steel and alloy steel

4291.1 Part 1: Bolts, screws and studs

4750 Electrogalvanized (zinc) coatings on ferrous hollow and open sections

AS/NZS

2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

3750 Paints for steel structures

3750.9 Part 9: Organic zinc-rich primer

4534 Zinc and zinc/aluminium-alloy coatings on steel wire

4680 Hot-dip galvanized (zinc) coatings on fabricated ferrous articles

ISO

4518 Metallic coatings—Measurement of coating thickness—Profilometric method

9223 Corrosion of metals and alloys—Corrosivity of atmospheres—Classification

12686 Metallic and other inorganic coatings—Automated controlled shot-peening of metallic articles prior to nickel, autocatalytic nickel or chromium plating, or as a final finish

3 DEFINITIONS

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

3.1 Local thickness

The mean of the thickness measurements, of which a specified number is made within a reference area.

3.2 Minimum local thickness

The lowest value of the local thickness found on the significant surface of a single article.

3.3 Significant surface

The part of the article covered or to be covered by the coating and for which the coating is essential for serviceability and/or appearance.

4 BASIS METAL

This Standard does not specify requirements for the surface condition of the basis iron or steel before electroplating with zinc. However, Appendix A requires that the electroplater be informed of surface condition requirements. This may be achieved by reference to AS 1627.0, which provides specifications for surface condition on metals. Other requirements may be illustrated by provision of acceptable type samples.

5 COATING SYSTEM

5.1 Basic system

A typical coating system for ferrous articles comprises—

(a) a zinc coating applied by a batch electroplating (electrogalvanizing) process;

(b) a supplementary chromate conversion coating or other passivation system; and

(c) an optional organic/inorganic coating.

Table 1 specifies the preferred zinc coatings. However, other coating specifications (zinc thicknesses) are permitted by negotiation between electroplater and purchaser or, in the case of ferrous commodities destined to be sold on the open market, at the discretion of the manufacturer concerned, but with the proviso that in no case shall any coating less than 5 micrometres minimum local thickness be permitted.

Where a zinc coating other than the preferred thicknesses listed in Table 1 is decided upon and agreed by the interested parties, the coating classification shall be analogous to those shown, e.g. for a 7 micrometre minimum local thickness, the coating classification becomes Fe/Zn 7.

A chromate conversion coating, complying with the requirements of Table 2 shall be applied to the zinc coating. However, the chromate conversion coating may be omitted, or replaced by another passivation system, but only at the specific request of the purchaser.

5.2 Supplementary system

An organic or inorganic coating, such as a clear lacquer, may be applied for additional corrosion protection, either by agreement between interested parties or, if the commodity is offered for general sale, at the manufacturer's discretion.

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TABLE 1

PREFERRED COATINGS OF ZINC ON IRON OR STEEL—COATING CLASSIFICATION CODE AND MINIMUM LOCAL THICKNESS

Zinc coating classification code	Minimum local thickness µm	Minimum equivalent coating mass g/m^2
Fe/Zn 5*	5	35
Fe/Zn 8*	8	55
Fe/Zn 12*†	12	85
Fe/Zn 25*†	25	180

* Followed by the appropriate symbol for the chromate conversion coating, when present (see Clause 6 and Table 2). Details of any other conversion coating shall be given separately.

† It is recommended that coatings with classification codes Fe/Zn 25 and Fe/Zn 12 receive a coloured, Class 2, chromate conversion coating (Designation C or D).

NOTES:

1 Other coating classifications are permitted (see Clause 6).

2 In any particular environment, the protective value of a zinc coating is directly proportional to its mass per unit area (surface density).

3 Two factors influence the relationship between service life and zinc coating mass: the environmental conditions of usage and the length of time the coating is required to provide protection. This matter is under investigation.

4 When very long service life is required, as for example on structural steel components, hot-dip galvanized coatings are recommended (see AS/NZS 4680).

TABLE 2

CLASSIFICATION OF CHROMATE CONVERSION COATINGS (SEE NOTE)

Chromate coating designation	Coating class	Coating type	Typical appearance	Coating mass g/m^2	Corrosion protection
A	1	Clear	Transparent clear, sometimes with bluish tinge	Up to 0.5	Slight, for example against staining or handling or against high humidity in mildly corrosive conditions
C	2	Iridescent	Yellow iridescence	1.0 to 1.5	Considerable, including protection against certain organic vapours
D	2	Opaque	Olive green, black, shading to brown or bronze	Greater than 1.5	

NOTE: Where chromate-free surfaces are requested, the letter 'N' shall be substituted for 'c' (see Clause 6, Note 2).

6 COATING CLASSIFICATION CODE

The coating classification code comprises:

(a) The chemical symbol, Fe, for the basis metal, iron or steel, followed in sequence by a solidus (/), the chemical symbol for zinc, Zn, and a number indicating the minimum local thickness, in micrometres, of the zinc coating (see Table 1).

(b) Symbols indicating the presence and class and designation of the chromate conversion coating shall be written in the same order as shown in the example in this Clause, (see Table 2).

NOTES:

1 No symbols are required to be shown for the lowest grade of chromate conversion coating, i.e. A.

2 Where other types of conversion coating are applied, the details should be shown separately.

A typical example of a coating code is Fe/Zn 25c2A where, additionally:

(i) 'c' refers to the chromate conversion coating.

(ii) '2' is the class of the chromate conversion coating.

(iii) 'A' is the designation of the chromate conversion coating.

7 HEAT TREATMENT

Heat treatment, as specified in Appendices D and E, shall be performed on certain grades of steel to reduce the risk of damage by hydrogen embrittlement.

It is important to note that parts made from steels with maximum specified tensile strengths greater than 1000 MPa* (corresponding hardness values are approximately 34 HRC, 340 HV and 325 HB) and surface-hardened parts will require heat treatment.

Preparation involving cathodic treatments in alkaline or acidic solutions shall be avoided.

NOTE: The selection of electroplating solutions with high cathodic efficiencies, for example fluoroboric solutions, is recommended for steel components with tensile strengths greater than 1450 MPa (corresponding hardness values of approximately 45 HRC, 440 HV and 415 HB).

8 ZINC WHISKER GROWTH

Electroplated zinc finishes are susceptible to metallic whisker, or trichite, growth. The mechanism of whisker formation is neither well understood nor predictable.

Electroplated zinc is commonly used as the protective coat over steel supporting structures and housings used in electronics equipment. For these applications, zinc whisker growth has proved to be a significant problem, particularly where low voltage circuits are involved.

It is strongly recommended to purchasers that zinc plating not be used for electronics equipment, unless zinc whisker growth is perceived to be of no consequence. Where zinc whiskers may result in equipment malfunction, purchasers are advised to choose an alternative protective coating.

9 ZINC COATING REQUIREMENTS

9.1 Appearance of zinc coating

Over the significant surface, the electroplated article shall be free from clearly visible plating defects such as blisters, pits, roughness, cracks or unplated areas other than those arising from defects in the basis metal. On articles where a contact mark is unavoidable, its position should be the subject of agreement between the interested parties.

The articles shall be clean and free from damage. However, damaged areas not exceeding 0.5% of the total zinc-coated surface area on an article, with no individual damaged area exceeding 40 mm^2, may be repaired unless specifically declined by the purchaser at the time of enquiry or order. Renovation methods are specified in Appendix F.

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* 1 MPa = 1 N/mm^2.

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Unless the purchaser specifies otherwise, the zinc coating shall be bright. If necessary, a specimen showing the required finish shall be supplied or approved by the purchaser.

9.2 Thickness of zinc coating

The minimum local thickness requirement of the zinc coating, as indicated by the classification code (see Table 1), or which is otherwise designated, shall apply to those portions of the significant surface that can be touched with a ball 20 mm in diameter. The minimum local thickness requirement shall also apply to additional portions of the significant surface if specified by the purchaser.

The minimum local thickness shall be determined in accordance with Clause 10.1.

In the case of articles having a significant surface area less than 100 mm^2, or where the basis metal is inherently rough (e.g. from shot-peening or abrasive cleaning), the minimum local thickness shall be deemed to be the minimum value of the average thickness determined by the method specified in Clause 10.1.

9.3 Adhesion of zinc coating

The coating shall continue to adhere to the basis metal when subjected to the test specified in Clause 10.2.

10 TEST METHODS FOR ZINC COATINGS

10.1 Thickness

Methods that are suitable for the measurement of zinc coatings on iron and steel are specified in AS 2331.1.1, AS 2331.1.2, AS 2331.1.3, AS 2331.2.1 and ISO 4518.

In case of dispute, the method specified in AS 2331.1.1 shall apply, except that, for articles having a significant surface of less than 100 mm^2, or where the basis metal is inherently rough (e.g. from shot-peening or abrasive cleaning), the method specified in AS 2331.2.1 shall be used.

If agreed between the electroplater and purchaser, test method AS 2331.2.1 may be used in all cases.

10.2 Adhesion

The adhesion test shall be in accordance with the burnishing test procedure specified in AS 2331.4.1.

11 CHROMATE CONVERSION COATINGS

11.1 General

Conversion coatings in general, and chromate coatings in particular, enhance the corrosion resistance of electrodeposited zinc coatings.

Chromate conversion coatings are soft when first produced and harden with age through gradual dehydration; it is important, therefore, that coatings be handled carefully for the first 24 h after treatment.

11.2 Classification of chromate conversion coatings

Chromate conversion coatings shall be classified in accordance with their chromate coating mass per unit area and with their typical appearance, as specified in Table 2.

12 REQUIREMENTS AND TESTS FOR CHROMATE CONVERSION COATINGS

12.1 General

Tests apply only to chromated surfaces that have not been subjected to any organic/inorganic supplementary treatment, and to coatings produced more than 24 h, but not more than 72 h, prior to testing.

NOTE: Tests performed on coatings outside these limits may require a different basis for assessment.

12.2 Presence

The chromate conversion coating shall be continuous over the zinc surface. The presence of Type A coating shall be verified by the method described in Appendix G.

12.3 Adhesion

Chromate coatings shall be adherent. Coloured coatings, Types C and D, shall be tested by one of the methods described in Appendix G.

12.4 Coating mass

When determined in accordance with Appendix G, the mass of the chromate conversion coating shall satisfy the limits shown in Table 2.

12.5 Corrosion resistance

When tested in accordance with AS 2331.3.1, AS 2331.3.8 and the requirements of Table 3, chromated items shall not show the presence of white corrosion products or any other form of deterioration of the conversion coating or corrosion of the basis metal.

Where the purchaser requests compliance with one only of the two test methods specified above, this shall be specified on the purchase order together with the test method to be applied.

TABLE 3

CORROSION TESTS FOR CHROMATE CONVERSION COATINGS

Chromate coating designation	Neutral salt spray resistance* duration h	Humidity resistance † Number of cycles
A	6	2
C and D	96	10

* Test method AS 2331.3.1.

† Test method AS 2331.3.8.

13 CONFORMANCE

A random sample of zinc-plated articles of the size required by AS 2483 shall be selected from the inspection lot and inspected for conformance to the requirements of this Standard. The lot shall be classified as conforming or not conforming to each requirement in accordance with the sampling plans in AS 2483.

14 IDENTIFICATION

Electroplated zinc (electrogalvanized) coatings produced to comply with this Standard shall be identified, both in marketing literature and on the articles themselves, or on individual consignments of articles, by the electroplater or commodity manufacturer, with at least the following information being shown:

(a) Trade name of electroplater or commodity manufacturer.

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(b) The number of this Standard, i.e. AS 1789.

(c) Electroplated zinc, or zinc plated, or electrogalvanized.

(d) The coating classification code in accordance with Clause 6.

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APPENDIX A

INFORMATION TO BE SUPPLIED TO THE ELECTROPLATER

(Normative)

The following information shall be supplied to the electroplater:

(a) The number of this Standard, i.e. AS 1789.

(b) The classification code (see Clause 6).

(c) The significant surface, indicated, for example, by drawings or by the provision of suitably marked specimens.

(d) The nature and surface condition and finish of the basis metal (see Clause 4).

(e) If appropriate, the surface appearance of the coating.

(f) Requirements for any heat treatment before and after electroplating (see Clause 7).

(g) The type of chromate coating (see Clause 11.2) or other conversion coating.

NOTES:

1 It should be noted that chromate conversion coatings may only be omitted, or alternative conversion coatings applied, at the specific request of the purchaser.

2 See Table 2 for appropriate designations.

(h) If sampling and inspection required are specified by the purchaser then sampling plan shall be specified in the purchase order.

(i) Any special requirements for, or restrictions on, preparation and electroplating.

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APPENDIX B

FACTORS THAT AFFECT THE CORROSION OF ZINC COATED ARTICLES

(Informative)

B1 GENERAL

This Appendix classifies environments in Australia and New Zealand that affect the corrosion of steel and the life of a coating system. When selecting an appropriate protective coating system, the overall environment in the location of the intended structure requires consideration. A structure situated in an aggressive environment will require a much higher standard of corrosion protection than one in a benign environment. The environment can affect both the steel and the coating system. Of prime importance is the effect the environment has on the corrosion of steel.

Corrosion of steel in pH-neutral environments generally requires the presence of moisture and oxygen. As long as a layer of moisture is present, corrosion rates are often controlled by the rate at which oxygen can get to the surface. Soluble contaminants such as salts can also have a major influence on corrosion rates. Steel corrosion rates are therefore very low in dry environments, higher in damp environments and very high in the presence of moisture and salt or other contaminants. In acidic environments, the corrosion rate of steel increases as the pH decreases. Alkaline environments generally give low corrosion rates for steel, except at very high pHs.

The effect of the environment on protective coatings can be different to its effect on steel. Zinc coatings are corroded by both acids and alkalis. Some organic coatings are damaged by extremes of pH, while others can resist such environments. High ultraviolet (UV) radiation, high humidity, intense rainfall and damp conditions can affect certain organic coatings. Tropical environments, for example, with high UV and humidity, which influences mould and fungal growth are far more aggressive to organic coatings than the corrosion rate of steel would suggest. The colour of a paint may influence the latter's performance in some environments.

The major factors that affect atmospheric corrosion, and hence atmospheric corrosivity categories based on ISO 9223, are given in this Appendix. This information has been used to classify atmospheric environments into a number of categories and these are discussed in Paragraph B2.

The effects of ultraviolet (UV) radiation, which are not covered in ISO 9223, should be considered separately, given the high levels of solar radiation in Australia and New Zealand.

Steelwork may be immersed in water, buried in soil, or exposed to other environments not specifically defined in any of the categories listed in Paragraph B2. Structures in such environments are subject to corrosion problems often of a completely different nature to atmospheric corrosion. Not only are different coating systems sometimes used, but a number of other corrosion prevention options, such as cathodic protection or selection of different materials should be considered. The selection of such prevention methods requires specialist advice and is outside the scope of this Standard.

B2 ATMOSPHERIC CORROSIVITY CATEGORIES

B2.1 General

Atmospheric environments are classified into five atmospheric corrosivity categories as described in Paragraph B2.2 to B2.6, plus one tropical category (Paragraph B2.7), which is

not determined by corrosion rate. All categories except tropical have been based on the corrosion rates of mild steel given in ISO 9223.

NOTE: If a site is considered to be in more than one category, for example an industry on the coast is in a tropical region, then a selected coating should be capable of resisting the most severe of the environments involved.

B2.2 Category A: Very low

Environments in this category are most commonly found inside heated or airconditioned buildings with clean atmospheres, such as most commercial buildings. They may also be found in semi-sheltered locations remote from marine or industrial influence and in unheated or non-airconditioned buildings. The only external environments in Australia or New Zealand are some alpine regions, although, generally, these environments will extend into Category B.

B2.3 Category B: Low

Environments in this category include dry, rural areas as well as other regions remote from the coast or sources of pollution. Most areas of Australia and New Zealand beyond at least 50 kilometres from the sea are in this category, which can, however, extend as close as 1 kilometre from seas that are relatively sheltered and quiet. Typical areas occur in arid and rural inland regions, most inland cities and towns such as Canberra, Ballarat, Toowoomba, Alice Springs and Hamilton (NZ), and suburbs of cities on sheltered bays, such as Melbourne, Hobart, Brisbane and Adelaide (except areas within 3 to 6 kilometres of the coast near Adelaide). Unheated or non-airconditioned buildings where some condensation may occur, such as warehouses and sports halls, can be in this category. Proximity to the coast is an important factor.

B2.4 Category C: Medium

This category mainly covers coastal areas with low salinity. The extent of the affected area varies significantly with factors such as winds, topography and vegetation. Around sheltered seas, such as Port Philip Bay, Category C extends beyond about 50 metres from the shoreline to a distance of about one kilometre inland. For a sheltered bay or gulf, such as near Adelaide, this category extends from the shoreline to about 3 to 6 kilometres inland. Along ocean-front areas with breaking surf and significant salt spray, it extends from about 1 kilometre inland to between 10 to 50 kilometres inland, depending on the strength of prevailing winds and topography. Much of the metropolitan areas of Wollongong, Sydney, Newcastle, the Gold Coast, Auckland and Wellington are in this category. In South Australia the whole of the Yorke Peninsula falls within this or a more severe category, and in the south-east of the state, from Victor Harbor to the Victorian border, this category extends between 30 and 70 kilometres inland. Such regions are also found in urban and industrial areas with low pollution levels and, although uncommon in Australia and New Zealand, exist for several kilometres around major industries, such as smelters and steelworks, and in the geothermal areas of New Zealand. Micro-environmental effects, such as result from proximity to airports and sewage treatment works, may also place a site into this category. Interior environments with Category C corrosivity can occur in humid production rooms, such as food-processing plants, laundries, breweries, printing works and dairies.

B2.5 Category D: High

This category occurs mainly on the coast. Around sheltered bays, Category D extends up to 50 metres inland from the shoreline. In areas with rough seas and surf, it extends from about several hundred metres inland to about one kilometre inland. As with Categories B and C, the extent depends on winds, wave action and topography. Industrial regions may also be in this category, but in Australia and New Zealand these are only likely to be found within 1.5 kilometres of the plant. This category extends inside the plant where it is best considered as a micro-environment. Damp, contaminated interior environments such as

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occur with swimming pools, dye works, paper manufacturers, foundries, smelters and chemical processing plants may also extend into this category.

B2.6 Category E: Very high (E-I: Industrial, E-M: Marine)

This category is common offshore and on the beachfront in regions of rough seas and surf beaches. The region can extend inland for several hundred metres. (In some areas of Newcastle, for example, it extends more than half a kilometre from the coast.) This category may also be found in aggressive industrial areas, where the environment may be acidic with a pH of less than 5. For this reason, Category E is divided into Marine and Industrial for purposes of coating selection. Some of the damp and/or contaminated interior environments in Category D may occasionally extend into this category.

B2.7 Category F: Inland Tropical

A tropical environment is found in coastal areas of north Queensland, Northern Territory, north-west Western Australia, Papua New Guinea and the Pacific islands, except where affected by salinity. Corrosivity in inland regions is generally low (similar to that of Category B), but the aggressiveness of the environment to organic coatings means special protection is required.

B3 MACROCLIMATIC EFFECTS

The two most important atmospheric factors on corrosion rate of both steel and zinc are time of wetness and level of airborne pollutants, the most significant of the latter being chloride salts, sulfur dioxide and hydrogen sulfide.

Time of wetness is the length of time during which the metallic surface is covered by a film of water that renders atmospheric corrosion possible. It is influenced by factors such as metal mass, exposure orientation and pollution, and can be quantified to sufficient accuracy in terms of the number of hours per year that the relative humidity is above 80% for temperatures above 0°C.

On a global scale, airborne chlorides (essentially sodium chloride), sulfur dioxide and hydrogen sulfide are all powerful stimulants for atmospheric corrosion, and their deposition rate in situations that are exposed to the elements (i.e. situations that are non-sheltered or rain washed) is directly proportional to their concentration in the atmosphere.

Saline aerosol (spray and mist) has a profound influence on corrosion rate, especially near the ocean. Zinc is relatively rapidly attacked in the vicinity of surf beaches, for instance.

The most corrosive pollutant in air is sulfur dioxide, which, in combination with time of wetness, causes abnormally high corrosion rates of zinc. In Australia, however, sulfur dioxide and also hydrogen sulfide have been found to play only a minor role in corrosion and can be neglected, except when occurring near recognized (usually microclimatic) sources, such as certain fossil fuel-burning industries or facilities (sulfur dioxide) and rotting vegetable matter, as in wetlands, or sewage treatment works (hydrogen sulfide).

In marine environments, and those affected by industrial or similar pollution, dew is likely to be contaminated with impurities that are corrosive to the metallic coating. In such circumstances, the corrosivity of the contaminant may be more important than the degree of moisture condensation.

Rainfall influences corrosion rate and has the effect of either stimulating or reducing corrosion, depending on the environment. In polluted or coastal atmospheres, the washing effect of rain reduces corrosion, while at less polluted sites or those well away from the ocean the situation is reversed and the corrosive action of rain is more important.

Temperature influences corrosion rate, but can have contradictory effects: increasing temperature accelerates the rate of the corrosion reactions, but, on the other hand, leads to

more rapid evaporation, thus shortening the time of wetness and decreasing the corrosion rate.

Zinc coatings develop a carbonate barrier layer to protect the steel and also sacrificially protect locations where discontinuities have occurred in the coating, often through damage. However, airborne chlorides, sulfur dioxide and hydrogen sulfide combine with, and change the behaviour of, this barrier layer. Being fairly soluble, the resultant altered compounds are dissolved by rainwater, thus leaving the coating itself relatively unprotected, and it quickly corrodes.

B4 MICROCLIMATIC AND OTHER EFFECTS

In addition to (macro) climatic effects, the local environment (or microclimate) and the circumstances of use of the zinc-coated article may present an influence, and therefore need to be taken into account, if the duration of corrosion protection sought is to be realized. For example, an article employed in a climate, classified as mildly corrosive, may have its useful life significantly shortened, if due consideration has not been taken of corrosive fumes from a nearby effluent-treatment plant, or from proximity to a busy highway or airport; in other words, microclimatic effects may have transformed a *Category B* environment, for example, into a localized *Category C*.

Factors that can significantly affect the corrosion rate of zinc-coated steel are as follows, and are provided for guidance:

(a) *Initial exposure conditions*

Constant rainfall and/or high humidity, especially under hot conditions, over the first few days of exposure can cause a higher initial corrosion rate of a relatively new zinc coating, since its protective carbonate layer may not have had time to form sufficiently (also see Item (g) below and the Note to Paragraph B5).

(b) *Protection from rain*

The corrosion rate in applications exposed to airborne salt and other contaminants, but shielded from rain, can be many times greater than would occur in rain-washed situations. This applies particularly to areas affected by fertilizer or insecticide drift and sea mist, where a zinc coating may become exhausted in 60% of the time when protected, compared with that when rain washed.

(c) *Prolonged dampness*

Corrosion will be promoted under conditions where the zinc coating remains damp for extended periods of time, such as where it is protected from the warming effects of the sun, where it is in contact with wet vegetation, or where it is subject to moisture retention or condensation. Articles that are exposed to spray from bore water are especially vulnerable to corrosion since prolonged dampness and salinity are influences different from the general atmospheric conditions in the vicinity.

(d) *Galvanic corrosion*

Galvanic corrosion of the zinc coating can occur where it is in direct metallic contact with, or in very close proximity (less than about 1 mm) to, a dissimilar, more noble (cathodic), metal in the presence of, or covered by, moisture. Examples of galvanic corrosion are as follows:

(i) A piece of copper or of uncoated (bare) steel attached to the coated article will accelerate attack of the metallic coating.

(ii) Similarly, but less obviously, stainless steel or aluminium will promote corrosion of zinc coatings, and this will be most evident under severe marine *(Category E)* exposure conditions.

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(e) *Burial in soils*

It should not be assumed that zinc-coated steel buried in soils in *Category B* regions will be relatively immune to corrosion, because the soil may contain salts and its moisture content may be reasonably high, thus providing a good electrolyte. For example, the clay pans in the vicinity of Birdsville in the arid, far southwest of Queensland are alkaline and very corrosive.

(f) *Organic and other chemical attack*

Zinc-coated articles should not be employed or stored in contact with cardboard or paper products, damp concrete or other moist surfaces, cinders, clinkers, unseasoned or freshly termite-proofed (e.g. copper-chrome-arsenate (CCA) treated) timbers, or harmful chemicals (e.g. lime, fertilizers and fungicides) or chemical vapours.

(g) *Barrier film removal*

Zinc coated articles rely for their durability on a thin barrier film of oxides and/or carbonates that forms on the surface during the early stages of their service. Any agent, such as an abrasive or chemical (e.g. fertilizer), which tends to modify or remove the protective film, will seriously reduce the useful life of the article. Wind erosion, where airborne sand or grit abrades the coating, is a common cause of reduced coating life in arid regions.

(h) *Animal enclosures*

Organic vapours, chemical substances, high levels of moisture, and contaminated fluids (e.g. by urine in and around enclosures for animals), must be considered when specifying zinc-coated items for their use.

(i) *Prevailing winds*

Contamination can be transported, usually unexpectedly, from one region to another by winds, and so this aspect requires consideration. For instance, CSIRO has reported that the apparently well-dispersed emissions from the high stacks of certain coal-burning electric power stations effectively doubled the corrosivity at localities up to 80 kilometres away.

B5 CORROSION DURING TRANSPORT AND STORAGE

Attention should be paid to the conditions of transport and storage of zinc plated (electrogalvanized) products, especially where no supplementary coating has been applied in manufacture, in order to avoid the possibility of wet-storage stain.

This unsightly stain of corrosive products, commonly known as ‘white rust’, can occur on newly zinc-coated items that are transported or stored under humid, badly ventilated conditions. However, while the wet-storage stain may detract from the as-produced appearance of the zinc-coated items, it is usually not detrimental, unless storage under the unsatisfactory conditions is prolonged.

Storage under tarpaulins or plastic sheeting, since these restrict the circulation of air, or storage under conditions in warehouses or sheds where condensation may occur, especially overnight through falling temperature, is not recommended. Ideally, zinc-coated items should be stored above ground (on racks, for example) and in warmed buildings, so that the relative humidity always remains low. (Zinc corrodes at a very slow rate in clean air where the relative humidity is below about 70%.)

When zinc-coated products are stored under inappropriate conditions, condensation can occur and moisture can be retained between abutting surfaces through capillary action. Since drying is delayed by lack of circulating air within the closely packed items, condensate retention is prolonged, and corrosion is thereby promoted.

Severe localized corrosion can also occur where items are stored on or touching cardboard or paper products, concrete (notably where seepage can occur), or damp surfaces, cinders, clinkers, unseasoned or freshly termite-proofed timbers or harmful chemicals, such as fertilizers and fungicides.

NOTE: In dry air, freshly applied zinc is slowly attacked by atmospheric oxygen, which then reacts with carbon dioxide, with consequent dulling of lustre, to form a thin, naturally protective film of basic zinc carbonate. However, when new zinc coatings are exposed to high humidity, especially under conditions of poor ventilation, a spongy deposit of zinc oxide or hydroxide forms and this then converts to the deposit of carbonate known as 'white rust'. Because of its nature, the deposit provides little barrier to the access of moisture to the zinc metal and prolongs the time of wetness. This effect is compounded if certain metallic impurities are co-deposited with the zinc.

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APPENDIX C

MAINTENANCE OF ZINC-PLATED ARTICLES

(Informative)

Cleaning is essential if the finish of zinc-plated steel is to be preserved and the original performance characteristics are to be maintained. Deterioration of the coating occurs mainly as a result of grime deposition and attack by contaminated moisture, which in a coastal environment contains chlorides and in an industrial or urban environment contains chlorides and sulfur compounds. Deposited grime, even if thin, absorbs moisture like a sponge and holds it against the zinc-coated surface; this permits corrosive attack, especially pitting, to proceed more aggressively than it otherwise would.

Recommendations for the frequency of cleaning are as follows:

(a) In a rural environment, where grime deposition and pollution are likely to be minimal, cleaning every six months may be sufficient to remove deposits and restore the appearance.

(b) In industrial and marine environments monthly cleaning is advisable; however, the maximum period between cleanings should never be more than three months. Under the worst conditions, involving heavy grime deposition and atmospheric pollution by both sulfur compounds and chlorides, more frequent cleaning is advisable, if accelerated deterioration of the coating is to be prevented.

(c) As a general rule for outdoors applications, zinc-plated steel should be cleaned at the same frequency as is required for windows. Washing with plain tap water and a brush is usually sufficient, but, if the deposits are heavy or greasy, a non-abrasive pH-neutral detergent solution should be employed. In the latter case surfaces should be thoroughly rinsed subsequently with clean water to remove residues.

Appendix F specifies methods of renovation where zinc plating is inadvertently scored or abraded, especially if the basis steel is exposed.

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APPENDIX D

PRETREATMENT OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT

(Normative)

D1 SCOPE

This Appendix establishes stress relief requirements for high strength steels in order to reduce their susceptibility or degree of susceptibility to hydrogen embrittlement in subsequent pretreatment, electroplating, chemical conversion, and phosphating processes. This Appendix is applicable to steels, the properties of which are not adversely affected by heat treatment at 190°C to 230°C or higher.

The heat treatment procedures established in this Appendix have been shown to be effective in reducing the susceptibility of steels having tensile strengths equal to or greater than 1000 MPa and that have been machined, ground, cold-formed or cold-straightened subsequent to heat treatment. This heat-treatment procedure is used prior to any operation capable of hydrogen charging the parts, such as the cleaning procedures prior to electroplating.

This Appendix does not apply to fasteners.

NOTES:

1 For hydrogen embrittlement of fasteners refer to AS 4291.1.

2 Severely cold-worked steels should be stress relieved.

D2 REQUIREMENTS

Heat treatment shall be performed on basis metals in order to reduce the risk of hydrogen embrittlement in accordance with Table D1. In all cases, the heat treatment shall be deemed to commence at the time at which the whole of each part attains the specified temperature.

Parts made from steel with actual tensile strengths greater than or equal to 1000 MPa (with corresponding hardness values of 300 HV, 303 HB and 31 HRC) and surface-hardened parts shall require heat treatment unless class SR-0 is specified. Preparation involving cathodic treatments in alkaline or acidic solutions shall be avoided.

Table D1 lists the stress-relief heat-treatment classes that may be specified by the purchaser to the electroplater, supplier or manufacturer on the part drawing or purchase order. When no stress relief treatment class is specified by the purchaser, then class SR-1 shall be applied.

NOTES:

1 The treatment class selected is based upon experience with the part, or similar parts, and the specific alloy used, or with empirical test data. Some parts, because of factors such as alloy composition and structure, size, mass or design parameters can perform satisfactorily with no stress-relief treatment. Therefore, class SR-0 treatment is provided for parts that the purchaser wishes to exempt from treatment.

2 The use of inhibitors in acid pickling baths does not necessarily guarantee that hydrogen embrittlement is minimized.

3 Class SR-1, the longest treatment, is the default when the purchaser does not specify a class. The electroplater, supplier or processor is not normally in possession of the necessary information, such as design considerations, induced stresses from manufacturing operations, that have to be considered in selecting the correct stress relief treatment. It is in purchasers' interests that their part designer, manufacturing engineer or other technically qualified individual specify the treatment class on the part drawing or purchase order so as to avoid the extra cost of the default treatment.

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D3 CATEGORIZATION OF STEELS

With the exception of surface-hardened parts, the heat treatment conditions shall be selected on the basis of actual tensile strength. When only the minimum tensile strength is specified, or if the tensile strength is not known, the heat treatment condition shall be selected by relating known or measured hardness values to equivalent actual tensile strengths. The tensile strength, or equivalent derived from known or measured hardness values, shall be supplied by the purchaser.

Steels that have been wholly or partly surface hardened shall be considered as being in the category appropriate to the hardness of the surface hardened layer.

D4 HEAT TREATMENT

D4.1 High strength steels

For high strength steels, the following conditions apply:

(a) For steels of actual tensile strength less than 1000 MPa, stress relief treatment is not essential.

(b) For steels of actual tensile strength greater than or equal to 1000 MPa, the conditions given in Table D1 shall apply.

The heat treatment shall be carried out before commencement of any preparation or cleaning treatment using aqueous solutions, or before any treatment liable to cause embrittlement.

D4.2 Shorter times at higher temperatures

Combinations of shorter times at appropriate higher temperatures may be used if they have been shown not to be detrimental. For tempered steels, articles shall not be heated above a temperature that shall be at least 5°C below the tempering temperature.

D4.3 Stress relief temperatures after shot peening

If stress relief is given after shot peening in accordance with ISO 12686 or other cold working processes to introduce beneficial compressive stresses, the temperature shall not exceed 230°C.

D4.4 Steels below 1400 MPa

For articles made of steel with actual tensile strengths below 1400 MPa, articles having surface hardened areas that would suffer an unacceptable reduction in hardness by treatment in accordance with Table D1 shall be heated-treated at a lower temperature, but at not less than 130°C, for a minimum period of 8 hours. Lower temperature heat treatment can adversely affect the fatigue strength of the article.

TABLE D1

CLASSES OF STRESS RELIEF REQUIREMENTS FOR HIGH STRENGTH STEELS

Class	Tensile strength of steels R_m MPa	Hardness HV	Hardness HB	Hardness HRC	Temperature °C	Minimum time hours
SR-0	Not applicable (see Paragraph C2, Note 1)					
SR-1	>1800	>547	>520	>52	200 to 230	24
SR-2*	>1800	>547	>520	>52	190 to 220	24
SR-3	1800	547	520	52	200 to 230	18
SR-4*	1800	547	520	52	190 to 220	18
SR-5*	1034	320	304	32	177 to 205	3
SR-6	1450	434	413	44	200 to 230	3
SR-7*	1450	449	427	45	190 to 220	1
SR-8	<1400	<434	<413	<44	130 to 160	8

* Traditional treatments referred to in some overseas national Standards.

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APPENDIX E

POST-COATING TREATMENTS OF IRON OR STEEL TO REDUCE THE RISK OF HYDROGEN EMBRITTLEMENT

(Normative)

E1 SCOPE

This Appendix establishes procedures for reducing susceptibility or degree of susceptibility to hydrogen embrittlement that can arise in surface finishing processes.

The heat treatment procedures established in this Appendix have been shown to be effective in reducing the susceptibility to hydrogen embrittlement. These heat-treatment procedures are used after surface finishing, but prior to any secondary conversion coating operation.

Stress-relief heat treatment procedures applied after fabrication, but prior to the electroplating process, are specified in Appendix D.

This Appendix does not apply to fasteners.

NOTES:

1 For hydrogen embrittlement of fasteners refer to AS 4291.1.

2 The heat treatment does not guarantee complete freedom from the adverse effects of hydrogen embrittlement.

E2 REQUIREMENTS

Heat treatment shall be performed on coated steels in order to reduce the risk of hydrogen embrittlement. In all cases, the heat-treatment shall be deemed to commence at the time at which the whole of each article attains the specified temperature.

Articles made from steels with actual tensile strengths greater than or equal to 1000 MPa (with corresponding hardness value of 300 HV, 303 HB, or 31 HRC) and surface-hardened parts shall require heat treatment unless class ER-0 is specified. Preparation involving cathodic treatment in alkaline or acidic solutions shall be avoided. Additionally, the selection of electroplating solutions with high cathodic efficiencies is recommended for steel components with tensile strengths greater than 1400 MPa (with corresponding hardness value of 425 HV, 401 HB, or 43 HRC).

Table E1 lists the embrittlement-relief heat-treatment classes from which the purchaser may specify the treatment required, to the electroplater, supplier or processor, either on the part drawing or on the purchase order. When no embrittlement-relief treatment class is specified by the purchaser, then class ER-1 shall be applied.

NOTES:

1 The treatment class selected is based upon experience with the part or similar parts, and the specific alloy used, or with empirical test data. Some parts, because of factors such as alloy composition and structure, trap-population density, size, mass or design parameters might perform satisfactorily with no embrittlement-relief treatment. Therefore, class ER-0 treatment is provided for parts that the purchaser wishes to exempt from treatment.

2 Class ER-1, one of the longer treatments, is the default when the purchaser does not specify a class. The electroplater, supplier or processor is not normally in possession of the necessary information, such as design considerations, induced stresses from manufacturing operations that have to be considered in selecting the correct stress relief treatment. It is in the purchasers' interests that their part designer, manufacturing engineer or other technically qualified individual specify the treatment class on the part drawing or purchase order so as to avoid the extra cost of the default treatment.

3 The use of inhibitors in acid pickling baths does not necessarily guarantee that hydrogen embrittlement is minimized.

E3 CATEGORIZATION OF STEELS

With the exception of surface-hardened parts, the heat treatment condition shall be selected on the basis of actual tensile strength. When only the minimum tensile strength, or if the tensile strength is not known, the heat treatment condition shall be selected by relating known or measured hardness values to equivalent tensile strengths. The tensile strength, or equivalent derived from known or measured hardness values, shall be supplied by the purchaser.

Steels that have been wholly or partly surface-hardened shall be considered as being in the category appropriate to the hardness of the surface-hardened layer.

If the purchaser requires any tests to be performed to verify adequate embrittlement relief treatment, then the test method and the sampling plan to be used shall be specified.

E4 HEAT TREATMENT AFTER PROCESSING

E4.1 General

The heat treatment shall commence as soon as possible, preferably within one hour, but not later than three hours after surface finishing and before commencement of any grinding or other mechanical operation. Heat treatment shall be carried out before any chromate conversion treatment.

NOTES:

1 Chromate coatings undergo changes at temperatures above 66°C. The coating changes from an amorphous structure to a crystalline structure and no longer exhibits 'self-healing' properties. Although the crystallized chromate coating will provide satisfactory corrosion protection under most natural environments, the chromate coating will no longer pass accelerated corrosion tests.

2 The time period referred to in Paragraph E4.4 is the time between the end of the plating and the loading of the article concerned into the heat treatment processor.

E4.2 High strength steels

For high strength steels, the conditions given in Table E1 and Figure E1 shall apply. For steels of actual tensile strengths less than 1000 MPa, heat treatment after plating is not essential.

E4.3 Threads and sharp notches

If threads or sharp notches exist or the articles are greater than 25 mm thick, heat treatment shall be carried out immediately after zinc electrodeposition for a minimum period of 24 hours.

E4 Surface-hardened, through-hardened, and bearing steels.

Electroplated steel articles having surface-hardened areas and through-hardened or bearing steels, that would suffer an unacceptable reduction in hardness by treatment in accordance with Table E1 and Figure E1 shall be heat treated at a lower temperature, but not at less than 130°C for a minimum period of 8 hours. For zinc-electroplated articles the minimum period shall be 16 hours for those with a tensile strength below 1400 MPa, and 22 hours for articles with a tensile strength in the range 1400 MPa to 1800 MPa.

NOTE: Lower temperature treatment may adversely affect the fatigue strength of the article.

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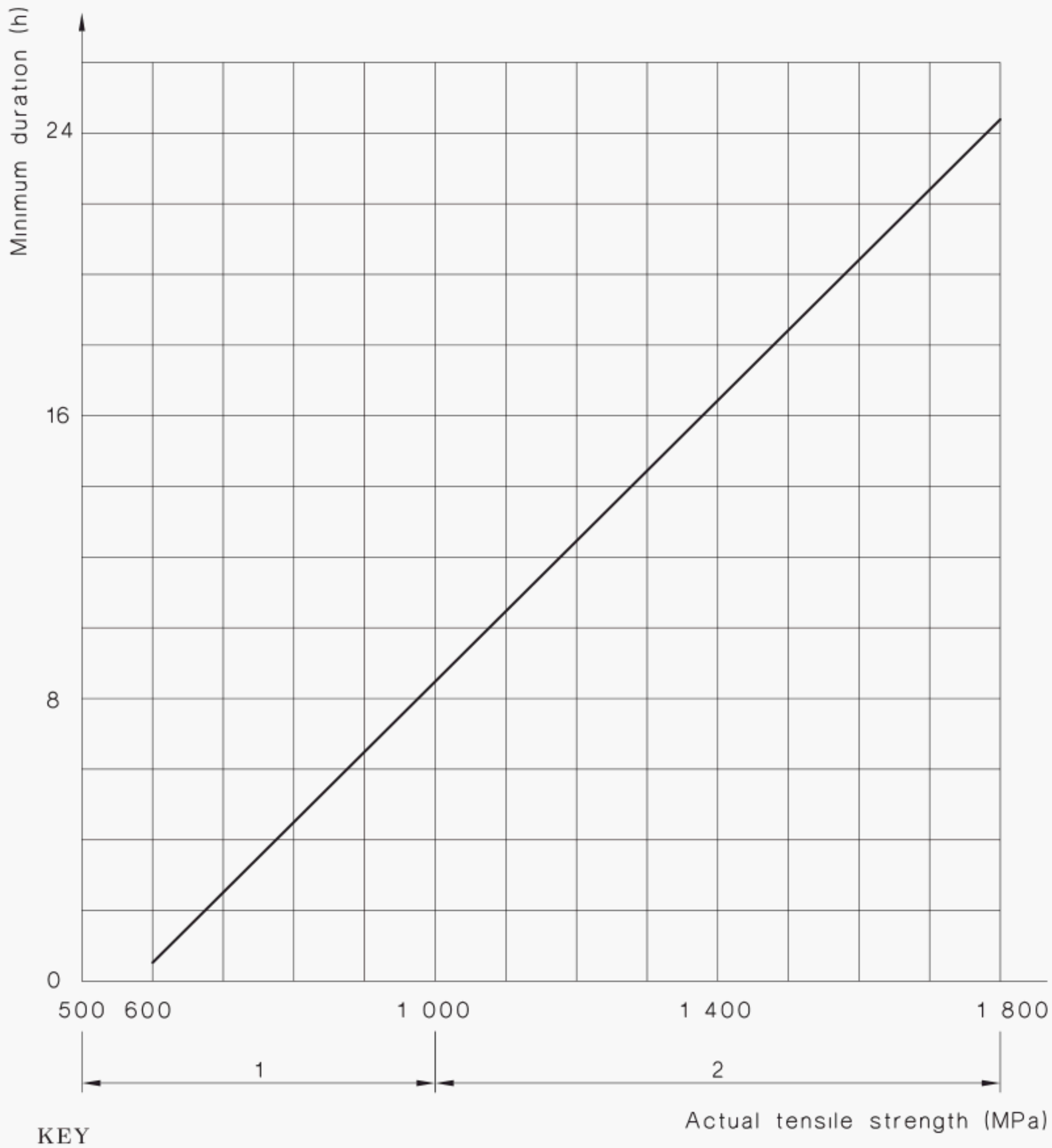

KEY
1 Non-mandatory
2 Mandatory

FIGURE E1 TIME-TENSILE STRENGTH RELATIONSHIP FOR HEAT TREATMENT AT A TEMPERATURE 190°C TO 220°C

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APPENDIX F

RENOVATION OF DAMAGED AREAS

(Normative)

Surfaces that have been damaged shall be repaired by the application of one of the following coatings:

(a) Organic zinc-rich primer complying with AS/NZS 3750.9. Apply two coats each having a minimum dry film thickness of 50 μm to the repaired areas.

NOTE: For subsequent powder coating, this coating system should be capable of passing 1000 hour neutral salt spray (NSS) performance, when tested in accordance with AS 2331.3.1 and should be stable under powder curing conditions.

(b) Zinc or zinc-alloy metal spray.

All coatings shall be applied in accordance with the manufacturers' recommendations, and, in the case of the coating given in Item (b), shall be at least 5 μm plus 100% of the minimum local zinc coating thickness.

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APPENDIX G

TEST METHODS FOR CHROMATE CONVERSION COATINGS ON ZINC COATINGS

(Normative)

G1 ADHESION TEST FOR TYPE C AND TYPE D CHROMATE CONVERSION COATINGS

Adhesion of Type C and Type D chromate conversion coatings shall be assessed by either of the following methods:

(a) *Paper method*

Rub the test surface for about 5 s with soft white tissue paper or No. 40 Whatman filter paper. After rubbing, the paper shall show no more than the faintest stain and the coating shall not show signs of having been rubbed through.

(b) *Eraser method*

Rub the test surface with a gritless gum eraser (art gum) for approximately 10 strokes using normal hand pressure and a stroke approximately 50 mm in length. After rubbing, the conversion coating shall not be removed or worn through to the underlying surface.

G2 SPOT TEST FOR THE PRESENCE OF A CHROMATE CONVERSION COATING

G2.1 Reagents for spot test solution

(a) Distilled or deionized water ..... 40 mL.

(b) Acetic acid (glacial) ..... 60 mL.

(c) Diphenylcarbazide ..... 1 g.

(d) Hydrochloric acid (concentrated) ..... 15 mL.

(e) Sodium hypochlorite (10-15 percent available chlorine) ..... 30 mL.

(f) Hydrogen peroxide (100 vol) ..... 5 mL.

G2.2 Method of preparation

The spot test solution shall be prepared as follows:

(a) Dissolve diphenylcarbazide in a mixture of glacial acetic and distilled water contained in a beaker.

(b) Add hydrochloric acid, stir and add slowly fresh sodium hypochlorite solution.

(c) Add slowly the hydrogen peroxide with continued stirring.

(d) Leave solution in the open beaker overnight to allow excess chlorine to escape. The solution is then ready for use. It does not deteriorate with age over a period of several months but tends to improve in efficiency.

NOTE: It should be kept, however, in a bottle with a loosely fitting glass stopper, since a slow evolution of chlorine continues over a considerable time.

G2.3 Test procedure

The spot test for the presence of chromate conversion coating shall be carried out by applying a drop of the test solution to the test surface.

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Formation of a red colour within 1 min indicates the presence of a chromate film.

G3 LEAD ACETATE TEST FOR THE ABSENCE OF A CHROMATE CONVERION COATING

G3.1 Reagents for lead acetate test

(a) Lead acetate.....50 g.

(b) Distilled or deionized water.....1 L.

G3.2 Method of preparation

Dissolve lead acetate in water and adjust the pH to 7.5 ±0.5.

G3.3 Test procedure

The lead acetate test for the absence of a chromate conversion coating shall be carried out by applying a drop of the test solution to the test surface and allowing to stand for 5 s following which the drop is gently removed without disturbance of any deposited film under the droplet.

The absence of a chromate coating shall be indicated by formation of a dark deposit or a black stain.

As a control and to ensure that test solution is working effectively, a zinc surface that is known to have not been chromated should also be tested.

G4 DETERMINATION OF THE MASS OF CHROMATE CONVERSION COATING

G4.1 Principle

Total chromate conversion coating is determined by removal of the film in an alkaline solution by electrolysis. The differences in mass of the test piece before and after the removal of the chromate coating is used to calculate mass of conversion coating per unit area.

G4.2 Test pieces

Test pieces should not weigh more than 200 g or be less than 5000 mm^2 in area.

G4.3 Electrolysis reagent

Dissolve 50 g of sodium or potassium cyanide and 5 g of sodium hydroxide in deionized or distilled water and make up to 1 litre.

G4.4 Procedure

The procedure shall be as follows:

(a) Determine mass of the test piece to the nearest milligram and then immerse the test piece as a cathode in the electrolysis reagent with the current switched on.

(b) Electrolyse at room temperature at a current density of 15 A/dm^2 (a period of approximately 60 s is required to effect the dissolution).

(c) After the conversion coating has been dissolved, remove test piece from the bath with the current still switched on.

(d) Wash test piece in clean water, dry and reweigh.

G4.5 Calculation

The mass of the conversion coating, in grams per square metre, shall be calculated from the following equation:

$$\text{Coating mass grams per square metre} = \frac{P_1 - P_2}{A} \times 1000$$

where

P_1 = mass of the coated test piece, in milligrams

P_2 = mass of the test piece after dissolution of the conversion coat, in milligrams

A = area of the test piece, in square millimetres

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