

Australian/New Zealand Standard™

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

Part 2: Hot dip galvanizing



AS/NZS 2312.2:2014

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee MT-014, Corrosion of Metals. It was approved on behalf of the Council of Standards Australia on 18 November 2014 and on behalf of the Council of Standards New Zealand on 26 November 2014.

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Australian Paint Manufacturers' Federation
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Australian/New Zealand Standard™

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

Part 2: Hot dip galvanizing

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee MT-014, Corrosion of Metals, to supersede, in part, AS/NZS 2312:2002, *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings*. It completely replaces references to hot dip coatings in AS/NZS 2312:2002, Section 5, and elsewhere in that document.

This Standard is Part 2 of a series for the protection of steel from corrosion, as follows:

AS/NZS

- 2312 Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
- 2312.1 Part 1: Paint coatings
- 2312.2 Part 2: Hot dip galvanizing (this Standard)
- 2312.3 Part 3: Thermally sprayed metallic coatings (in preparation)

This Standard does not cover thermal metal spray coatings, including zinc coatings and zinc-alloy coatings, which are the subject of AS/NZS 2312.3 (in preparation).

The objective of this revision is to provide guidelines for the proper specification and design of hot dip galvanized articles in the atmosphere. In preparing this Standard, reference was made to the ISO 14713 series, *Zinc coatings—Guidelines and recommendations for the protection of iron and steel in structures*.

This Standard should be used in conjunction with the relevant manufacturing Standards.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard**Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings****Part 2: Hot dip galvanizing****1 SCOPE**

This Standard provides guidelines and recommendations regarding general principles of design, appropriate for articles to be hot dip galvanized for corrosion protection. The application of zinc coatings by hot dip galvanizing provides an effective method of retarding or preventing corrosion of ferrous materials. Zinc coatings are used in this regard because they protect iron and steel both by barrier action and by galvanic action.

The protection afforded by the zinc coating to the article will depend on the method of application of the coating, the design of the article (both of which directly influence the thickness of the zinc coating), and the specific environment to which the article is exposed. The zinc coated article can be further protected by application of additional coatings, such as organic coatings (paints or powder coatings). When applied to hot dip galvanized articles, this combination of coatings is often known as a 'duplex system'.

This Standard applies to hot dip galvanized coatings applied by the following processes:

- (a) Hot dip galvanized coatings, applied after fabrication. (See Clause 5.1.2.)
- (b) Hot dip galvanized coatings, applied onto continuous sheet. (See Clause 5.1.3.)
- (c) Hot dip galvanized coatings, applied onto continuous cold-formed shapes. (See Clause 5.1.4.)

Other zinc coating processes covered in this Standard are the following:

- (i) Mechanically plated coatings (see Clause 5.1.5).
- (ii) Electrodeposited coatings (see Clause 5.1.6).

Specific product-related requirements (e.g. for hot dip galvanized coatings on tubes or fasteners, etc.) will take precedence over these general recommendations.

2 REFERENCED DOCUMENTS

The following documents are referred to in this Standard:

NOTE: Documents that may be referred to for additional information are listed in the Bibliography.

AS

1074	Steel tubes and tubulars for ordinary service
1214	Hot-dip galvanized coatings on threaded fasteners (ISO metric coarse thread series)
1397	Continuous hot-dip metallic coated steel sheet and strip—Coatings of zinc and zinc alloyed with aluminium and magnesium
1442	Carbon steels and carbon-manganese steels—Hot rolled bars and semi-finished products
1447	Hot-rolled spring steels

AS	
1789	Electroplated zinc (electrogalvanized) coatings on ferrous articles (batch process)
1830	Grey cast iron
1832	Malleable cast iron
1897	Electroplated coatings on threaded components (metric coarse series)
2309	Durability of galvanized and electrogalvanized zinc coatings for the protection of steel in structural applications—Atmospheric
4100	Steel structures
4291	Mechanical properties of fasteners made of carbon steel and alloy steel
4291.1	Part 1: Bolts, screws and studs
4312	Atmospheric corrosivity zones in Australia
4506	Metal finishing—Thermoset powder coatings
4750	Electrogalvanized (zinc) coatings on ferrous hollow and open sections
5016	Metallic materials—Conversion of hardness values
5056	Metallic coatings—Powder metal (and composites) applied by mechanical means at ambient temperature
AS/NZS	
1163	Cold-formed structural steel hollow sections
1594	Hot-rolled steel flat products
2041	Buried corrugated metal structures (series)
2312	Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings
2312.1	Part 1: Paint
2312.3*	Part 3: Thermally sprayed metallic coatings
2699	Built-in components for masonry construction
2699.3	Part 3: Lintels and shelf angles (durability requirements)
3678	Structural steel—Hot-rolled plates, floorplates and slabs
3679	Structural steel
3679.1	Part 1: Hot-rolled bars and sections
3679.2	Part 2: Welded I sections
4671	Steel reinforcing materials
4680	Hot-dip galvanized (zinc) coatings on fabricated ferrous articles
4791	Hot-dip galvanized (zinc) coatings on ferrous open sections, applied by an in-line process
4792	Hot-dip galvanized (zinc) coatings on ferrous hollow sections, applied by a continuous or a specialized process
NZS	
3404	Steel Structures Standard
3404.1	Part 1: Materials, fabrication, and construction

* To be published.

- ISO
- 2063 Thermal spraying—Metallic and other inorganic coatings—Zinc, aluminium and their alloys
 - 8044 Corrosion of metals and alloys—Basic terms and definitions
 - 9223 Corrosion of metals and alloys—Corrosivity of atmospheres—Classification, determination and estimation
 - 9224 Corrosion of metals and alloys—Corrosivity of atmospheres—Guiding values for the corrosivity categories
 - 12944 Paints and varnishes—Corrosion protection of steel structures by protective paint systems
 - 12944-5 Part 5: Protective paint systems
 - 12944-8 Part 8: Development of specifications for new work and maintenance

ASTM

- B117 Standard Practice for Operating Salt Spray (Fog) Apparatus

Australian Building Codes Board
National Construction Code of Australia

3 DEFINITIONS

For the purposes of this Standard, the terms and definitions given in AS 4312, AS/NZS 4680, ISO 8044, and those below apply.

3.1 Atmospheric corrosion

Corrosion with the earth's atmosphere at ambient temperature as the corrosive environment.

3.2 Elevated temperatures

Temperatures between +60°C and +200°C.

3.3 Exceptional exposure

Special cases, such as exposure that substantially intensifies the corrosive exposure and/or places increased demands on the corrosion protection system.

3.4 Hot dip galvanized coating

Coating obtained by hot dip galvanizing.

NOTE: The term 'hot dip galvanized coating' is subsequently referred to as the 'coating'.

3.5 Hot dip galvanizing

Formation of a coating of zinc and/or zinc/iron alloys on iron and steel products by dipping prepared steel or cast iron in a zinc melt.

3.6 Life to first maintenance

The time interval that can elapse after initial coating before coating deterioration reaches the point when maintenance is necessary to restore protection of the base metal.

4 MATERIALS—IRON AND STEEL SUBSTRATES

In hot dip galvanizing, the reactivity of the steel is modified by its chemical composition, particularly by the silicon plus phosphorus contents (see Clause 9.1).

Most steels, including unalloyed carbon steels and fine-grained steels (e.g. AS/NZS 1594, AS/NZS 3678, AS/NZS 3679.1, AS/NZS 3679.2, AS 1442, and AS 1447), hollow sections that are cold finished (e.g. AS/NZS 1163 and AS 1074), reinforcement steels (e.g. AS/NZS 4671), and fastener grade steels (e.g. AS 4291.1), can be galvanized. Where other ferrous metals are to be galvanized, adequate information or samples should be provided by the specifier for the galvanizer to decide whether these steels can be satisfactorily galvanized. Sulfur-containing free-cutting steels are normally unsuitable (e.g. AS 1442 S1214 grade).

Steel can be hot rolled or cold formed. Hot rolling is used to produce angle, 'I', 'H' and other structural sections and these sections are normally only batch hot dip galvanized (see Clause 5.1.2). Some structural sections (e.g. tubes, pipes and purlins) are cold formed and these can be batch hot dip galvanized or in-line galvanized (see also Clause 5.1.4).

Cast and wrought irons of various metallurgical and chemical compositions (e.g. grey cast iron [AS 1830] and malleable cast iron [AS 1832]) can be hot dip galvanized according to AS/NZS 4680. Special consideration is needed regarding the cast irons most suitable for hot dip galvanizing (see Clause 9.3).

5 ZINC COATINGS

5.1 Types of coating

5.1.1 General

The specifier should be aware of the available types of zinc coating and take these distinctions into account when designing articles (see Clause 7). Importantly, the corrosion protection in any particular environment is directly related to the thickness of the coating (see Table 6.2).

5.1.2 Hot dip galvanized coatings (applied after fabrication to AS/NZS 4680 and AS 1214)

Coating where, after suitable pretreatment, fabricated iron or steel articles are dipped in a bath containing a zinc melt. Typically, this process is used on pre-fabricated articles requiring longer term corrosion protection, including those articles that are centrifuged and non-centrifuged.

The design practice for coating to AS/NZS 4680 differs from that for other coating systems. Detailed guidance on the design practice is provided in Clauses 8 and 9.

5.1.3 Hot dip galvanized coatings (applied onto continuous sheet to AS 1397)

Coating where, after suitable pretreatment, sheet materials are continuously fed through a zinc melt and the hot dip galvanized sheet materials formed are used to fabricate a semi-finished structural article, such as purlins.

Post-galvanizing fabrication, such as bending, drilling and cutting may create uncoated areas, which will reduce the life of the formed article unless additional protective steps are taken.

The coating thickness of these products is measured as a total applied zinc mass, and the thickness of the coating (and hence the corrosion protection) may not be the same on each side of the sheet.

NOTES:

- 1 Other coating thickness and alloys are given in AS 1397, in addition to coatings with longer durability than the coatings from AS 1397 described in this Standard.
- 2 The design practice for continuous galvanizing to AS 1397 is available from specialist manufacturers.

5.1.4 *Hot dip galvanized coatings (applied onto continuously cold-formed shapes to AS/NZS 4791 and AS/NZS 4792)*

Coating where, after suitable pretreatment, coil materials are continuously fed through a zinc melt and the hot dip galvanized coil materials are cold formed into structural shapes within the process line of the galvanized article (commonly known as in-line galvanizing). Shapes formed include light structural sections (AS/NZS 4791) and cold formed tube (AS/NZS 4792).

Post-galvanizing fabrication such as bending, drilling, cutting and welding may create uncoated areas, which will reduce the life of the formed article unless additional post-fabrication protective steps are taken.

Some in-line galvanized tubular sections have no internal coating, while others have a different internal coating thickness from the external coating thickness. Hence, the internal corrosion protection requirement has to be taken into account by the designer (see Clause 7.2).

The design practice for continuous galvanizing to AS/NZS 4791 and AS/NZS 4792 is available from specialist manufacturers.

5.1.5 *Mechanically plated coatings (to AS 5056)*

Coating where, after suitable pretreatment, a zinc powder is mechanically applied to the surface of the steel article, usually by tumbling in a barrel. The articles coated are typically fasteners and other small items ancillary to the main structural components.

NOTE: Further information is available from the manufacturers of the finished articles.

The design for mechanical coating to AS 5056 is best discussed with specialist applicators; in general, these processes are most suitable for small parts which can be tumbled in a barrel but specialist plants may be available for other shapes.

5.1.6 *Electrodeposited coatings (to AS 1789, AS 1897 or AS 4750)*

Where, after suitable pretreatment, materials have a coating of zinc attached to the surface of the steel using the electroplating process. In some cases, electrodeposited coil material is further processed by slitting, roll forming and welding the coil into articles such as cold formed tubing (AS 4750), where the coating in the area of the heat affected zone (HAZ) of the weld is repaired as part of the tube manufacturing process.

Post-electroplating fabrication such as bending, drilling, cutting and welding may create uncoated areas, which will reduce the life of the formed article unless additional post-fabrication protective steps are taken.

NOTE: Further information is available from the manufacturers of the finished articles.

The design for electroplating with zinc to AS 1789 and AS 1897 follows the general design principles for electroplating.

The design for use of articles manufactured to AS 4750 is available from specialist manufacturers.

5.2 Selection of hot dip galvanized coating

The hot dip galvanized coating system to be used should be selected by taking the following items into account:

- (a) The design life of the coated article determined from Standards (e.g. AS 4100, NZS 3404.1), the asset owner's expectations, or other available sources (e.g. the National Construction Code of Australia).

- (b) The site specific corrosivity category, taking into account the general environment (macro-climate) and the effects of any local variations in the environment (microclimate), including anticipated future changes and any exceptional exposure (see Clause 6.1 and Table 6.1).
- (c) The life to first maintenance available options (see Table 6.2) taking into account the general principles of design to avoid corrosion (Clause 7.1) and whether tubular sections require internal protection (Clause 7.2).

NOTE: The life to first maintenance of some or all of the options may be less than the required design life, meaning that the coated article may require maintenance during the design life to maintain the structural integrity of the article.

- (d) The need for, and effect of, ancillary components such as bolted and welded connections on the overall durability of the coated article (see Clause 7.3).
- (e) The ease of maintenance of the coated article (see Clause 7.4) if the life to first maintenance of the coated article or ancillary components is less than the required durability.

NOTES:

- 1 A hot dip galvanized article may be designed for disassembly and re-galvanizing to extend its practical life. Alternatively, the article may be painted on site to extend its practical life, in the same way as an initially painted steel article (see AS/NZS 2312.1).
- 2 The life for a coating in any particular atmospheric exposure condition is approximately proportional to the thickness of the coating (see Table 6.2).

- (f) The need for painting the coated article, either initially (duplex system) or touch-up painting when the hot dip galvanized coating is approaching the end of its life to first maintenance (see Clause 7.5 and Table 7.1).

NOTE: A duplex coating may be specified for decorative or other reasons not related to durability of the coated article. Maintenance is often required at more frequent intervals because of paint fading, chalking, contamination, wear and tear, for aesthetic or other reasons.

- (g) The cost and availability of the options, including any required maintenance.

NOTE: If there are no suitable options the specifier should consider a design change, alternative materials (e.g. stainless steel) or alternative protection methods.

The operational sequence for applying the selected system should be determined in consultation with the steel fabricator and the applicator of the coating system.

6 CORROSION IN THE ATMOSPHERE

6.1 General

The corrosion rate of a zinc coating is affected by the time for which it is exposed to wetness, air pollution and contamination of the surface. To a first approximation, the corrosion of all zinc surfaces is at the same rate in a particular environment. The corrosion rates for zinc are much slower than for steel and often decrease with time. Iron and steel will normally corrode 10 to 40 times faster than zinc, the higher ratios usually being in high-chloride environments. The corrosion rate for zinc and for zinc-iron alloy layers in a hot dip galvanized coating are approximately the same.

NOTES:

- 1 For general information on the atmospheric corrosion rate for zinc, see ISO 9224.
- 2 For information on the major factors that affect atmospheric corrosion in Australia, see AS 4312.
- 3 For information on the major factors that affect atmospheric corrosion in New Zealand, see NZS 3404.1.

Table 6.1 gives basic groups of environments (related to ISO 9223). Where the relative humidity is below 60%, the corrosion rate of iron and steel is negligible and they may not require coating (e.g. inside many buildings). A hot dip galvanized coating with or without painting may; however be required for appearance or for reasons of hygiene (e.g. in a food factory).

When the relative humidity is higher than 60% or where they are exposed to wet or immersed conditions or prolonged condensation then, like most metals, iron and steel are subject to more serious corrosion. Contaminants deposited on the surface, notably chlorides and sulfates, accelerate attack. Substances that deposit on the surface of the iron and steel increase corrosion if they absorb moisture or go into solution on the surface of the iron and steel. Deposition of chlorides in coastal areas is strongly dependent on the variables influencing the transport inland of sea salt (e.g. wind direction, wind velocity, local topography, wind sheltering islands beyond the coast, distance of the site from the sea, etc.). The temperature also influences the corrosion rate of unprotected iron and steel and temperature fluctuations have a stronger effect than the average temperature value.

NOTES:

- 1 In Australian capital cities, the level of atmospheric sulfur dioxide (SO₂) is very low (typically averaging no more than 8 µg/m³). For the most part this means that the effects of pollution can be ignored. However, there are special cases (for example, near industrial plants) where the concentration of SO₂ should be determined during at least 1 year and is expressed as the annual average.
- 2 Change in atmospheric environments occurs with time. For many regions, the concentrations of pollutants (particularly SO₂) in the atmosphere have reduced with time. This has led to a lowering of the corrosivity for these regions, which, in turn, has led to the hot dip galvanized coatings experiencing lower corrosion rates compared to historical corrosion performance data. An example of this is the closure of the BHP Steel Works in Newcastle. Other regions have experienced increasing pollution and industrial activity and, therefore, would be expected to develop environments more accurately described by higher corrosivity.
- 3 Extreme influence of chlorides, which is typical of marine splashing or heavy salt spray, is beyond the scope of this Standard.

The micro-environment (that is, the conditions prevailing around the structure) is also important because it allows a more precise assessment of the likely conditions than the study of the basic climate alone. The micro-environment is not always known at the planning stage of a project. Every effort should be made to identify it accurately because it is an important factor in the total environment against which corrosion protection is required.

NOTE: An example of a microclimate is sheltered and not rain-washed surfaces, in a marine atmospheric environment where chlorides are deposited and where the article can experience a higher corrosivity category due to the presence of hygroscopic salts.

The corrosion of steelwork inside buildings is dependent on the internal environment but in 'normal' atmospheres (e.g. dry and heated) it is insignificant. Steelwork in the perimeter walls of buildings is influenced by the configuration within the perimeter wall (e.g. steelwork without direct contact with the outer leaf of a wall comprising two parts separated by an air space is at less risk of corrosion than steelwork in contact with or embedded in the outer leaf). Buildings containing industrial processes, chemical environments, wet or contaminated environments should be given special consideration, as these are beyond the scope of this Standard. Steelwork that is partially sheltered (e.g. farm sheds and aircraft hangars) should be considered as being subjected to the exterior environment.

Table 6.1 also sets out an indication of the likely range of corrosion rates that are applicable to zinc coatings exposed to the different types of corrosivity category dealt with in ISO 9223.

6.2 Atmospheric corrosivity in Australia and New Zealand

Examples of typical external atmospheric conditions in Australia and New Zealand are described below. These descriptions are developed from AS 4312 and NZS 3404.1. If there is any doubt as to the corrosivity category, professional advice should be sought.

Category C1 (Very low) The only external environments in Australia or New Zealand are some alpine regions although generally these environments will extend into Category C2.

Category C2 (Low) External 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 km from the sea are in this category, which can however extend as close as one 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 and Hobart. Proximity to the coast is an important factor.

Category C3 (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 C3 extends beyond about 50 m from the shoreline to a distance of about one kilometre inland. For a less sheltered bay or gulf, such as near Adelaide, this category extends from 100 metres from the shoreline to about 3 to 6 km inland. Along ocean front areas with breaking surf and significant salt spray, it extends from about 1 km inland to between 10 to 50 km 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 Harbour to the Victorian border, this category extends between 30 and 70 km 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.

Category C4 (High) This category occurs mainly on the coast. Around sheltered bays, Category C4 extends up to 50 m 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 C2 and C3, 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 km of the plant. This category extends inside the plant where it is best considered as a micro-environment.

Category C5 (Very High) 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 5.5.

Category CX (Extreme) These regions are found at some surf beach shoreline regions with very high salt deposition. Such corrosion rates would also be found in severe acidic industrial environments.

NOTE: This new category is not covered in the 2008 edition of AS 4312 or the 2009 edition of NZS 3404.1.

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

6.3 Life to first maintenance of coatings

6.3.1 General

Table 6.2 indicates the life to first maintenance for a selection of hot dip galvanized and other zinc coatings exposed to the range of standard corrosivity categories. The minimum and maximum life expectancies are indicated for each chosen system and durability class indicated. Durability is classified into the following classes:

- (a) Very short term (VS) 0 to ≤ 2 years.
- (b) Short term (S) 2 to < 5 years.
- (c) Medium term (M) 5 to < 10 years.
- (d) Long term (L) 10 to < 15 years.
- (e) Very long term (VL) 15 to < 25 years.
- (f) Extra long term (EL) ≥ 25 years.

Table 6.2 also provides guidance for coatings applied to structural and cold-forming grades of hot dip galvanized sheet and cold-rolled sections, on electrogalvanized and hot dip galvanized tube, and for articles hot dip galvanized after manufacture. Hot dip galvanized fabricated and semi-fabricated products made from thin material and fasteners and other centrifuged work usually have intermediate thicknesses of coating (e.g. AS 1214). As the life of all hot dip galvanized coatings is approximately proportional to the thickness or mass of zinc coating present, the relative performance of such intermediate thicknesses can readily be assessed.

Table 6.2 does not take into account any micro-environment experienced by the article (Clause 6.1). If the specifier is in any doubt as to the overall corrosivity category likely to be experienced by the article, expert advice should be sought.

The figures for life in Table 6.2 have been rounded to whole numbers. The allocation of the durability designation is based on the average of the minimum and maximum of the calculated life to first maintenance. For example, 85 μm hot dip galvanized coating in corrosivity Category C4 (corrosion rate for zinc between 2.1 μm per annum and 4.2 μm per annum from Table 6.1), gives an expected maximum durability of $85/2.1 = 40.746$ years (rounded to 40 years) and an expected minimum durability $85/4.2 = 20.238$ years (rounded to 20 years). The average durability of $(20 + 40)/2 = 30$ years is therefore designated 'EL'.

NOTES:

- 1 Corrosivity Categories C1 and C2 are not included in the Table as the zinc coating systems listed with a coating thickness more than 36 μm will achieve at least a minimum life to first maintenance of 50 years in C1 and C2 corrosivity zones, which exceeds the typical design requirements of most Standards and Codes such as the National Construction Code of Australia.
- 2 The list of systems given in Table 6.2, classified by environment and typical time to first maintenance, indicates the hot dip galvanized coating options open to the specifier. The recommended treatments listed for longer lives will always protect for shorter periods and also are economical for these shorter periods.

6.3.2 Criteria for assessing when to repair or regalanize

Repair or regalanizing of hot dip galvanized coatings should be carried out when about 2% of the surface in any particular area is showing signs of rusting.

NOTES:

- 1 Surface staining of iron/zinc alloys of unpainted hot dip galvanized coatings should be ignored unless it is aesthetically unacceptable.
- 2 See AS/NZS 2312.1 for schematic representations of surface rusting.

6.4 Accelerated test methods applied to zinc coatings

Accelerated test methods should not be used to predict the life to first maintenance of zinc-coated steel unless appropriate corroborating long-term atmospheric exposures have been conducted.

NOTE: Efforts have been made in many zinc-coated steel applications to develop the correct test method to determine a proper 'accelerated' lifetime. One test for corrosion prevention systems in the United States is ASTM B117; however, the test results obtained from that Standard seldom correlate to real life performance in natural environments and cannot be used to accurately test zinc-coated steel because the test accelerates the wrong failure mechanism. Without a proper wet/dry cycle, the zinc coating cannot form patina layers. The absence of a patina layer allows constant attack of the zinc metal and gives a very low prediction of the zinc coating lifetime.

ISO 9224 provides guiding values for long-term corrosion rates of zinc-coated steels which are based on a large number of exposures in many locations throughout the world; however, the procedure used in ISO 9224 cannot possibly cover all the situations that can occur in natural environments and service conditions. In particular, situations (e.g. as described in Clause 6.1) that result in significant changes in the environment can cause major increases or decreases in corrosion rates. Users of this Standard are cautioned to consult with qualified experts in the field of outdoor atmospheric corrosion in cases where localized corrosion can be more significant than general attack.

TABLE 6.1
DESCRIPTION OF TYPICAL ATMOSPHERIC ENVIRONMENTS

Corrosivity Category C, corrosion rate for zinc (based on one year exposures), r_{corr} ($\mu\text{m}/\text{year}$), and corrosion level	Typical environments (examples from ISO 9223)	
	Indoor	Outdoor
C1 $r_{\text{corr}} \leq 0.1$ Very low	Heated spaces with low relative humidity and insignificant pollution (e.g. offices, schools, museums).	Dry or cold zone. Atmospheric environment with very low pollution and time of wetness (e.g. certain deserts, central Antarctica).
C2 $0.1 < r_{\text{corr}} \leq 0.7$ Low	Unheated spaces with varying temperature and relative humidity. Low frequency of condensation and low pollution (e.g. storage, sport halls).	Temperate zone with an atmospheric environment with low pollution ($\text{SO}_2 < 5 \mu\text{g}/\text{m}^3$) (e.g. rural areas, small towns). Also, dry or cold zone with an atmospheric environment with short time of wetness (e.g. deserts).
C3 $0.7 < r_{\text{corr}} \leq 2.1$ Medium	Spaces with moderate frequency of condensation and moderate pollution from production process (e.g. food-processing plants, laundries, breweries, dairies).	Temperate zone with an atmospheric environment with some effect of chlorides, or medium pollution (SO_2 : $5 \mu\text{g}/\text{m}^3$ to $30 \mu\text{g}/\text{m}^3$) (e.g. coastal areas with low deposition of chlorides, urban areas). Also, subtropical and tropical zones with an atmosphere with low pollution.
C4 $2.1 < r_{\text{corr}} \leq 4.2$ High	Spaces with high frequency of condensation and high pollution from production process (e.g. industrial processing plants, swimming pools).	Temperate zone with substantial effect of chlorides or an atmospheric environment with high pollution (SO_2 : $30 \mu\text{g}/\text{m}^3$ to $90 \mu\text{g}/\text{m}^3$) (e.g. coastal areas without spray of salt water, polluted urban areas, industrial areas). Also, subtropical and tropical zones with an atmosphere with medium pollution.
C5 $4.2 < r_{\text{corr}} \leq 8.4$ Very high	Spaces with very high frequency of condensation and/or with high pollution from production process (e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical and tropical zones).	Temperate and subtropical zones with an important effect of chlorides and/or an atmospheric environment with very high pollution (SO_2 : $90 \mu\text{g}/\text{m}^3$ to $250 \mu\text{g}/\text{m}^3$) (e.g. coastal areas, sheltered positions on coastline, industrial areas).
CX $8.4 < r_{\text{corr}} \leq 25$ Extreme	Spaces with almost permanent condensation or extensive periods of exposure to extreme humidity effects and/or with high pollution from production process (e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides and corrosion-stimulating particulate matter).	Subtropical and tropical zones (very high time of wetness) and an atmospheric environment with strong effect of chlorides and/or very high pollution (SO_2 higher than $250 \mu\text{g}/\text{m}^3$), including accompanying production pollution (e.g. coastal and offshore areas with occasional contact with salt spray, extreme industrial areas).

NOTE: Corrosion rates exceeding the upper limits in Category C5 are considered extreme. Corrosivity Category CX refers to specific marine and marine/industrial environments. In environments with an expected 'CX category', it is recommended to determine the atmospheric corrosivity classification from one year corrosion losses.