



Atmospheric corrosivity zones in Australia



AS 4312:2019

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- Bureau of Steel Manufacturers of Australia
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- Energy Safe Victoria
- Galvanizers Association of Australia
- Materials Australia
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Preface

This Standard was prepared by the Australian members of the Joint Standards Australia/Standards New Zealand Committee MT-014, Corrosion of Metals, to supersede AS 4312—2008.

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

The objective of this Standard is to provide guidelines for the classification of atmospheric environments in terms of their effects on corrosion to assist with the selection of metal finishes for ferrous products.

This edition includes the following major changes from the previous edition:

- (a) Description of and identification of regions within the ISO CX severe corrosivity classification.
- (b) More accurate definition of locations within corrosivity categories, especially in tropical regions, and redrawing the corrosivity maps.
- (c) Removal of the industrial and marine sub-sections of the C5 and the Tropical category, to achieve complete correlation with the ISO categories.
- (d) Additional information on identifying internal environments.

The term “informative” has been used in this Standard to define the application of the appendix to which it applies. An “informative” appendix is only for information and guidance.

Contents

Preface	ii
Section 1 Scope and general	1
1.1 Scope	1
1.2 Application	1
1.3 Normative references	1
1.4 Terms and definitions	1
Section 2 Factors affecting corrosion of metals	3
2.1 General	3
2.2 Macro-climatic factors	3
2.2.1 Primary factors	3
2.2.2 Modifying factors	4
2.3 Micro-climatic and design factors	5
2.3.1 General	5
2.3.2 Industrial pollutants and chemical attack	5
2.3.3 Shelter from rain and regular washing	5
2.3.4 Screening from salt and pollution deposition	5
2.3.5 Prolonged surface wetness	5
2.3.6 Abrasion and erosion	6
2.3.7 Other factors	6
2.4 Corrosivity categories	6
2.5 Atmospheric corrosion — Metals other than steel	6
2.5.1 General	6
2.5.2 Stainless steels	7
2.5.3 Zinc	7
2.5.4 Aluminium	7
2.5.5 Aluminium-zinc alloys	7
2.5.6 Copper	8
Section 3 Corrosivity environments	9
3.1 General	9
3.2 Atmospheric corrosivity categories	9
3.2.1 C1: Very Low (mild steel corrosion rate < 1.3 µm/y)	9
3.2.2 C2: Low (mild steel corrosion rate 1.3 µm/y to 25 µm/y)	9
3.2.3 C3: Medium (mild steel corrosion rate 25 µm/y to 50 µm/y)	9
3.2.4 C4: High (mild steel corrosion rate 50 µm/y to 80 µm/y)	10
3.2.5 C5: Very High (mild steel corrosion rate 80 µm/y to 200 µm/y)	10
3.2.6 CX: Extreme (mild steel corrosion rate 200 µm/y to 700 µm/y)	10
Section 4 Determining the corrosivity environment	11
4.1 General	11
4.2 Determining the external corrosivity environment	11
4.3 Internal environments	12
Appendix A (informative) Corrosion categories	14
Appendix B (informative) Measurement of corrosion rates	23
Appendix C (informative) Corrosivity sections in other standards	25
Bibliography	27

NOTES

Australian Standard®

Atmospheric corrosivity zones in Australia

Section 1 Scope and general

1.1 Scope

This Standard provides guidelines for the classification of atmospheric corrosivity zones in Australia and their effect on the corrosion of steel and other metals.

The guidelines in this Standard use the corrosion rate classifications defined in ISO 9223 to delineate atmospheric corrosivity zones.

Environments that are not atmospheric, such as immersed, underground and splash zones, are not considered in this Standard. For these environments, refer to AS 2159 (piling) or AS/NZS 2041.1 (buried corrugated metal structures).

1.2 Application

This Standard is intended to be used by designers and specifiers of corrosion control methods to assist in determining the correct atmospheric corrosivity zone in Australia. The influence of micro climates is also addressed and should be considered when specifying the necessary corrosion protection that is required.

In general, a knowledge of atmospheric corrosivity is necessary in the following corrosion mitigation activities:

- (a) Selection of protective coatings such as paint coatings according to AS 2312.1 or hot dip galvanized coatings according to AS/NZS 2312.2. A more severe environment will normally require a higher performance or thicker coating system, or both.
- (b) Selection of in-line pre-coated products and suitable metals. The durability of in-line pre-coated products and metals such as copper and stainless steels depends on the corrosivity of the environment.
- (c) Maintenance of protective coating systems. In severe environments, maintenance is more difficult and usually required more frequently than in less severe environments.
- (d) Design of products and components such as fasteners. The importance of minimizing corrosion through careful design and fabrication procedures becomes more important as the environment becomes more corrosive.

NOTE AS 2312.1 and AS/NZS 2312.2 provide details of selection and maintenance of protective coatings, and include design features for minimizing corrosion.

1.3 Normative references

There are no normative references in this document.

NOTE The documents referenced in this Standard and additional reading matter are listed in the Bibliography.

1.4 Terms and definitions

For the purpose of this Standard, the following terms and definitions apply.

1.4.1

corrosion rate

amount (thickness or mass loss) of corrosion that occurs in a given time

Note 1 to entry: Corrosion rate is usually measured in micrometres (µm) per year.

1.4.2**corrosivity**

measure of the ability of the environment to cause corrosion

Note 1 to entry: Although “corrosivity” is an action and “corrosion rate” the effect of this action, the two terms are used interchangeably in this Standard.

1.4.3**corrosivity category**

standardized rating according to ISO 9223 of corrosivity of the atmosphere in relation to the first year corrosion rate

1.4.4**environment**

surrounding region that contains one or more corrosive agents

1.4.5**macro environment (or macro climate)**

environment generated by normal weather patterns in a specific area

1.4.6**micro environment (or micro climate)**

restricted or small-scale environment modified by local features such as the built environment, vegetation, topography, local pollution or the complexity or orientation of a structure

Section 2 Factors affecting corrosion of metals

2.1 General

Atmospheric corrosion of metals requires the presence of oxygen and an electrolyte, usually water (moisture). In such an environment, corrosion rates are controlled by the percentage of time that the surface is wet. Soluble contaminants such as salts are hygroscopic and have a major influence on corrosion rates, by absorbing moisture and creating a layer of electrolyte when none would otherwise exist, or by increasing the effective conductivity of the electrolyte. Corrosion rates are very low in dry, non-contaminated environments (of the order of 1 $\mu\text{m}/\text{y}$ for steel) but are higher (of the order of 20 $\mu\text{m}/\text{y}$ to 30 $\mu\text{m}/\text{y}$ for steel) in damp but non-polluted environments. Corrosion rates are very high, often over 100 $\mu\text{m}/\text{y}$ for steel, in the constant presence of moisture when combined with salt or other contaminants.

2.2 Macro-climatic factors

2.2.1 Primary factors

The two most important factors affecting the corrosion rates of metals in Australia are:

- (a) Time of wetness, which is the period of time during which a metallic surface is covered by adsorptive and/or liquid films of electrolyte that are capable of causing atmospheric corrosion. Moisture is mandatory for atmospheric corrosion to occur and, all things being equal, the longer the period of time that a layer of moisture is present on a metallic surface, the greater is the amount of corrosion. Time of wetness is influenced by a range of factors, for example metal type, the shape, mass and orientation of the object, any sheltering and pollutants on the surface. The length of time for which the relative humidity (RH) exceeds 80 % at a temperature greater than 0 °C has been used to estimate time of wetness.
- (b) Airborne salt, which is a major stimulant of atmospheric corrosion near the coast, causes the most damage to infrastructure in Australia as most of the population live within 50 km of the coast. Many common metals are rapidly attacked near surf beaches. The deposition rate of sea salt on exposed surfaces is directly related to its concentration in the atmosphere. Deposition, and therefore corrosion, usually drops off rapidly with distance travelled inland.

The rapid change in corrosivity for steel with distance inland is shown in [Figure 2.1](#). There is significant scatter in these results as factors such as local variations in weather, winds and local topography all affect the amount of salt in the air and the amount deposited at a given site. The marine influence is not consistent although the results do tend to divide into distinct groups:

- (i) Near rough seas or surf beaches, for example Newcastle, the corrosivity figures are very high, falling away rapidly moving inland. At about 0.5 km to 1 km inland, the figures generally tend to flatten out, but still remain quite high, averaging around 50 $\mu\text{m}/\text{y}$ for steel up to 3 km or more inland.
- (ii) Around sheltered coastal waters, for example Melbourne, results are completely different. Right on the shoreline corrosivity is high, reaching 60 $\mu\text{m}/\text{y}$ or 70 $\mu\text{m}/\text{y}$, but significantly less than figures obtained near ocean surf. The results level out moving inland more than 500 m or so in such an environment, suggesting no further marine influence.
- (iii) In tropical environments, corrosion rates can be very high right at the shoreline but drop away rapidly moving inland. On sheltered tropical coasts, such as along the reef coast in Queensland, corrosivity falls away quickly to levels similar to temperate sheltered bays about 1 km inland. Fewer surveys have been carried out in such environments, and scatter in results is far greater.

Many locations will not fall exactly into one of these groups and a range of corrosivity behaviour is observed. Corrosion rates vary considerably within 100 m or so from a beachfront. [Figure 2.1](#) may be used to estimate approximate atmospheric corrosivity for sites with environments similar to those plotted.

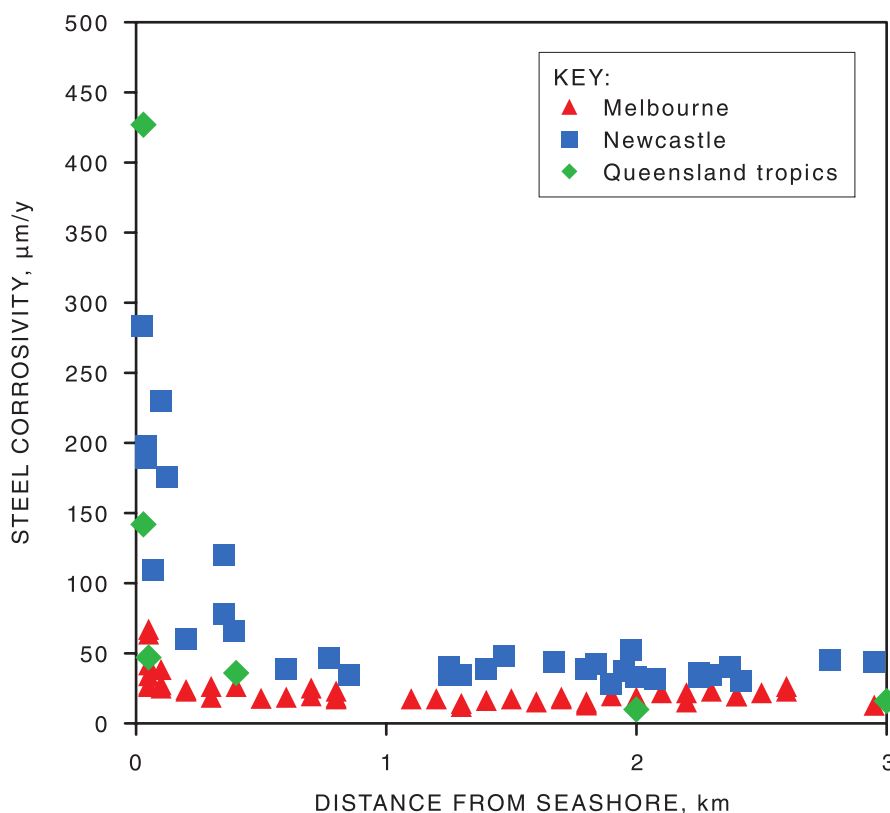


Figure 2.1 — Effect of distance from seashore on steel corrosivity

2.2.2 Modifying factors

Other macro-climatic factors that influence corrosion rates, in a less predictable manner, are as follows:

- Rainfall has the effect of either stimulating or reducing corrosion depending on the environment. In polluted or coastal atmospheres, the washing effect of the rain can reduce corrosion by removing contaminants, while at less polluted sites or those well away from the ocean the situation is reversed and higher rainfall increases the time of wetness, raising corrosivity.
- Temperature also has contradictory effects. Increasing temperature increases the rate of corrosion reactions but leads to more rapid moisture evaporation, shortening the time of wetness and decreasing the corrosion rate.
- Wind can increase corrosion rate by carrying salts and other corrosion contaminants considerable distances from their source. Alternatively, winds can dry a wet surface lowering the time of wetness and corrosion rate.
- Topography has an influence on corrosion rates. High cliffs or hills near the coast cause salt to deposit out and corrosion rates decrease on the leeward sides of such features. Low lying, flat regions such as at the mouth of the Murray in South Australia allow wind to travel well inland and high corrosion rates due to salt deposition have been found 100 km or more inland from rough seas in particularly flat, windy locations.

2.3 Micro-climatic and design factors

2.3.1 General

In addition to the macro-climatic effects on corrosion, micro-climatic effects and design at a given site should be taken into consideration. These factors can interact to transform a mildly corrosive atmosphere into an aggressive one or vice versa.

2.3.2 Industrial pollutants and chemical attack

Sulfur dioxide (SO₂) and other sulfur-bearing compounds, other gaseous corrosive substances and acidified rain are powerful stimulants of atmospheric corrosion. In some parts of the world they are considered a macro-climatic factor in corrosion. However, as there are limited sources of these pollutants in Australia, they are generally an isolated contributor to atmospheric corrosion of metals and are best considered a micro-climatic factor. They may be disregarded except at sites near recognized point sources, such as fossil fuel burning industries and smelters of sulfide ores.

Pollution levels around large industries, and thus corrosion rates, were higher in the past. Many of these industries have closed or significantly lowered their emissions and so corrosion rate survey results may show little relation to current corrosion rates.

Other types of pollution such as particulates, oxides of nitrogen (NO_x), acidic, alkaline or other chemical fallout and cooling tower mist also increase corrosion rates. Vapours, waste products, fertilizers, fungicides and other chemicals and fluids in and around animal and other farming activities are generally corrosive.

2.3.3 Shelter from rain and regular washing

As noted in Item (a) of [Clause 2.2.2](#), surfaces exposed to atmospheric contaminants such as marine salts, agricultural chemicals and other contaminants, but sheltered or shielded from the washing action of rain, may show a corrosion rate significantly greater than would occur in a rain-washed situation. This may be a design issue as well as a micro-climatic effect.

Regular rain washing will generally reduce corrosion rates. However, in regions with little atmospheric contamination, exposure to rain or regular washing increases corrosion rates.

2.3.4 Screening from salt and pollution deposition

Corrosivity surveys are normally carried out with panels boldly exposed to the local environment. However, structures and buildings may be screened (as distinct from sheltered) by other constructions erected between them and the corrosion source, which intercept the deposition of corrosives such as wind-blown sea salt. In such cases, the salt deposition may be significantly reduced as will local corrosivity. Alternatively, interruption of the wind flow may cause eddies leading to increased salt deposition. Little work has been carried out to quantify such effects. The effect of screening will be far less in milder categories where time-of-wetness is a major contributor to corrosivity.

2.3.5 Prolonged surface wetness

Locations where the metal remains wet for an extended period, such as surfaces that are not freely draining (“ponding areas”) or surfaces shaded from drying effects of sunlight or wind, will show higher corrosion rates. Other examples include surfaces subject to condensation, impingement by steam or those in contact with wet vegetation.

Corrosivity survey data that have produced the values referred to in this Standard have usually been derived by using vertical or inclined flat, smooth panels. A “real” structure with horizontal surfaces, edges, ponding areas, rough welds, crevices, gussets, enclaves and other such features that trap water is likely to show higher corrosion rates.

2.3.6 Abrasion and erosion

Abrasion and impact of exposed surfaces will in time remove protective films and hence reduce the surface life of the material or coating, e.g. wind erosion, handling, traffic and livestock.

2.3.7 Other factors

There are many other factors that influence the corrosion rate of a metal at a given site, with some being of greater importance than others. [Appendix B](#) discusses some of these, as well as macro-environmental effects such as the effect of randomness in weather patterns and exposure conditions on the outcome of corrosion rates determined by field exposure. These factors explain why there is considerable variation in corrosion figures from nominally similar sites.

2.4 Corrosivity categories

For practical use of corrosivity figures, corrosion rate figures should be divided into categories that correlate with corrosion protection requirements, such as durability of materials or performance of protective coatings. ISO 9223 describes six corrosivity categories based on the first year corrosion rate of mild steel and other metals, as shown in [Table 2.1](#). ISO 9223 and related standards also allow estimation of the same corrosivity categories based on environmental factors such as time of wetness and chloride deposition rate (a procedure known as “dose-response function”). In AS 4312, the first year corrosion rate of mild steel has been used to define corrosivity categories, rather than one of the other methods described in the ISO standards. There are three main reasons for this:

- (a) Most surveys have been carried out in Australia using only steel specimens. Far fewer surveys have been carried out using other metals.
- (b) There is little data on time of wetness, salt deposition and SO₂ concentration available in this country to use these figures to determine the corrosivity category using the “dose response function”.
- (c) The corrosivity category, as determined by the corrosion rate of a different metal or the dose response function, may not correlate to the steel corrosivity category.

Table 2.1 — Corrosivity categories according to ISO 9223

ISO 9223 category	Corrosivity	First year corrosion rate of metals, µm/y			Typical environment
		Carbon steel	Zinc	Copper	
C1	Very low	< 1.3	< 0.1	< 0.1	Dry indoors
C2	Low	1.3–25	0.1–0.7	0.1–0.6	Arid/urban inland
C3	Medium	25–50	0.7–2.1	0.6–1.3	Coastal or light industrial
C4	High	50–80	2.1–4.2	1.3–2.8	Sea-shore (calm)
C5	Very high	80–200	4.2–8.4	2.8–5.6	Sea-shore (surf)
CX	Extreme	200–700	8.4–25	5.6–10	Shoreline (severe surf)

2.5 Atmospheric corrosion — Metals other than steel

2.5.1 General

The corrosion rates of other metals will be much less than for steel in the same environment. Generally, the corrosion properties of metals other than steel will follow the same trends as for steel; that is, as the environment becomes more severe, their corrosion rate will increase. [Clauses 2.5.2, 2.5.3, 2.5.4, 2.5.5](#) and [2.5.6](#) note some general observations regarding atmospheric corrosion of other common metals.