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**Editorial**
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# HOT DIP GALVANIZED STEEL = DURABLE STEEL

No other protective coating for steel provides the long life, durability, and predictable performance of hot dip galvanizing. An alloy of its steel base, a galvanized coating is unique in matching the design and handling characteristics of steel with its inertness to the high to extreme UV levels prevailing over the Australian continent.

As asset management and life cycle costing become even more essential, after-fabrication hot dip galvanizing provides a predictable, engineered result.

Hot dip galvanized steel will normally corrode 10 to 40 times slower than bare steel, depending on the environment. In addition, zinc, the core element of the hot dip galvanizing process, is a naturally occurring element, is essential for life and is 100% recyclable.

The life to first maintenance (LFM) of a hot dip galvanized article is the time interval which elapses after the initial coating of the steel until the galvanizing deteriorates to the point when maintenance is necessary to restore protection of the steel base. The LFM is a function of both the thickness of the zinc alloy coating (which is, by itself, a function of the thickness of the steel), and the nature of the environment.

*Story continued on page 2*

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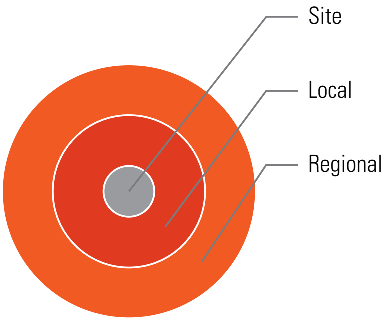
# THE ENVIRONMENT






The schematic diagram above shows the three key elements of the environment which affect the life of any steel structure.

Determination of the regional or **macro environment** is done through reference to the long-term climatic conditions for a particular area (for example using the available Bureau of Meteorology data, such as rainfall, temperature and relative humidity), the levels of airborne salinity and pollution levels i.e. sulfur dioxide levels. In Australia, the major population centres are located in the temperate (Sydney, Melbourne, Adelaide) or sub-tropical (Brisbane, Perth) zones, but each has a very different corrosion performance due to airborne salinity. The level of pollution in Australia's major cities is typically very low and is normally ignored.

Specifiers must also take into account the micro environment of any hot dip galvanized article. The **micro environment** is made up of the local conditions (for example natural topography, the built environment or vegetation) and site conditions (for example water ponding, sheltering of the structure from local rain or other building materials in contact with the structure). These can create very different local effects. The effects can sometimes be difficult to estimate and may change quite significantly over the lifetime of a structure – potentially increasing or decreasing the estimated life by many years.

**Daintree Discovery Centre.** Far North Queensland, this is typically a C2 zone for HDG, but most paints will require maintenance to maintain their life.

## Corrosivity Zones

The corrosivity of particular environments, called Corrosivity Zones, have been widely researched and the corrosion rates of both steel and zinc are divided into six general categories. Table 1 shows the comparative corrosivity rate of mild steel and zinc for the first year of service in various environments.

The corrosion rate table uses the internationally recognised standard corrosion rates for mild steel and zinc metal from ISO 9223. Note that the corrosion rate for the first year is typically higher than the measured long-term averages.

The Categories are somewhat arbitrary as their purpose is to provide guidance to designers on expected corrosion zones, hence the significant variation of corrosion rates within each zone. If a designer needs information that is more accurate then they should seek out specific testing data for the location concerned.

**Carousel Building.** Geelong foreshore (Corio Bay), this is typically a C4 zone.

To assist specifiers in determining their macro environment, AS 4312 includes a guide for users describing typical Australian locations and conditions based on the ISO categories. The GAA has further developed this Guide (back page) using the latest extensively updated commentary on the various climatic conditions in the 2012 edition of ISO 9223. By using these guidelines and Chart 1, specifiers can make an estimate of the macro environment and therefore the LFM for hot dip galvanized steel for any coating thickness.

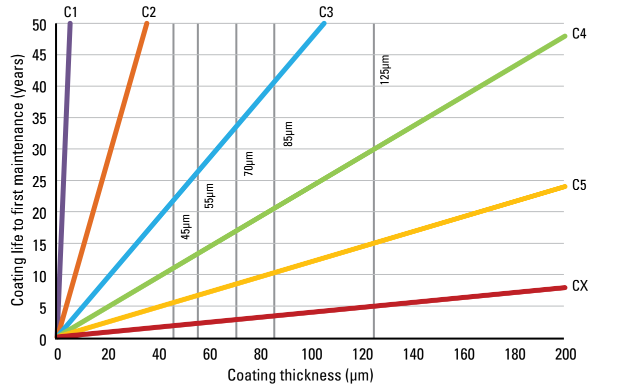
**Table 1: Standard Corrosion Rates for Metals in Atmospheric Conditions**

| Corrosivity Zones (ISO 9223) | | Typical environment | Corrosion rate for the first year of exposure (µm/annum) | |
|---|---|---|---|---|
| Category | Description | | Mild steel | Zinc |
| C1 | Very low | Dry indoors | ≤1.3 | ≤0.1 |
| C2 | Low | Arid/ Urban inland | >1.3 to ≤25 | >0.1 to ≤0.7 |
| C3 | Medium | Coastal or industrial | >25 to ≤50 | >0.7 to ≤2.1 |
| C4 | High | Calm sea-shore | >50 to ≤80 | >2.1 to ≤4.2 |
| C5 | Very High | Surf sea-shore | >80 to ≤200 | >4.2 to ≤8.4 |
| CX | Extreme | Ocean/Off-shore | >200 to ≤700 | >8.4 to ≤25 |

**Table 2: Durability of Hot Dip Galvanizing in Atmospheric Conditions**

| Steel Thickness mm | Coating thickness | | Corrosivity Zone and Range of Life to First Maintenance (years) | | | |
|---|---|---|---|---|---|---|
| | µm | g/m2 | C3 | C4 | C5 | CX |
| > 1.5, ≤ 3.0 | 55 | 390 | 26/79 | 13/26 | 7/13 | 2/7 |
| > 3.0, ≤ 6.0 | 70 | 500 | 33/100 | 17/33 | 8/17 | 3/8 |
| > 6.0 | 85 | 600 | 40/100+ | 20/40 | 10/20 | 3/10 |
| >> 6.0 | 125 | 900 | 60/100+ | 30/60 | 15/30 | 5/15 |

**Chart 1: Time to First Maintenance Chart for Hot Dip Galvanized Steel to AS/NZS 4680**




Developed from ISO 9223 and ISO 14713 data.

# Predictability and Durability of Hot Dip Galvanizing

The hot dip galvanizing process has been in use for over 175 years and the predictability of corrosion rates of hot dip galvanizing has been tested in many environments and locations around the world.

The durability of hot dip galvanizing is assessed in any environment by comparing the thickness of the coating with the corrosion rate in the chosen Corrosivity Zone (see Table 2). The Australian Standard for hot dip galvanizing (AS/NZS 4680) provides information on standard thicknesses, based on the underlying steel substrate. For example, a steel article over 6mm thick will have a minimum of 85 µm and in a C4 zone, a life to first maintenance of between 20 and 40 years. When a structure is close to a more corrosive zone, then the life to first maintenance will be towards the lower end of the prediction.

Note that hot dip galvanized coatings thicker than 85 µm are not specified in AS/NZS 4680 but the general provisions apply and, together with specific thickness figures, may form a specification capable of third-party verification, as per the 125 µm example shown in Table 2. Many structural steel elements (for example, most hot rolled I-beams and channels) are significantly thicker than 6 mm. It is essential to know the composition of the steel to be used (from the test certificate) and the galvanizer should be consulted before specifying, as these thicker coatings may not be available for all types of steel. Where the steel is suitable, thick coatings may be specified.

The Guide can also be represented as per Chart 1 for any zinc thickness and all Corrosivity Zones. They are based on macroscopic environmental data and thus may vary from the actual corrosion rate observed, due to site-specific environmental conditions. This chart and the guidelines for its use are also available separately from the GAA.

**Sydney desalination plant.**

C5 Interior due to an aggressive industrial atmosphere. Note the Duplex coat of epoxy paint in the lower regions of the structure to provide additional protection from the micro environments.

# Guide: Determining the Macro-Environment for Indoor and Outdoor Conditions

| | | |
|---|---|---|
| Are you within a subtropical or tropical zone (very high time of wetness) with an atmospheric environment consisting of very high pollution ($SO_2$ > 250 µg/$m^3$) including accompanying & production factors &/or strong effect of chlorides (e.g. extreme industrial areas, ocean & offshore areas, occasional contact with salt spray)?<br>Are you in a space with almost permanent condensation or extensive periods of exposure to extreme humidity effects &/or with high pollution from production process, e.g. unventilated sheds in humid tropical zones with penetration of outdoor pollution including airborne chlorides & corrosion-stimulating particulate matter? | Yes → | **Extreme Corrosivity CX** |

**No ↓**

| | | |
|---|---|---|
| Are you within a temperate or subtropical zone with an atmospheric environment consisting of very high pollution (90 µg/$m^3$ < $SO_2$ ≤ 250 µg/$m^3$) &/or significant effect of chlorides, e.g. industrial areas, jetties & other offshore structures, within a few hundred metres of the ocean & sheltered positions on the coastline?<br>Are you in a space with very high frequency of condensation &/or with high pollution from production process, e.g. mines, caverns for industrial purposes, unventilated sheds in subtropical & tropical zones? | Yes → | **Very High Corrosivity C5** |

**No ↓**

| | | |
|---|---|---|
| Are you in a temperate zone with an atmospheric environment consisting of high pollution (30 µg/m3 < SO2 ≤ 90 µg/m3) or substantial effect of chlorides, e.g. less than two kilometres from polluted urban areas, industrial areas or between a few hundred metres & a kilometre of the ocean or within one hundred metres of sheltered coastal areas without spray of salt water?<br>Are you in a subtropical or tropical zone with an atmosphere with medium pollution?<br>Are you in a space with high frequency of condensation & high pollution from a production process, e.g. industrial processing plants, swimming pools? | Yes → | **High Corrosivity C4** |

**No ↓**

| | | |
|---|---|---|
| Are you in a temperate zone with an atmospheric environment with medium pollution (5 µg/$m^3$ < $SO_2$ ≤ 30 µg/$m^3$) or some effect of chlorides, e.g. urban areas, between a kilometre & twenty to fifty kilometres (depending on winds & topography) from the ocean, or within one hundred metres of sheltered coastal areas with low deposition of chlorides?<br>Are you in a subtropical or tropical zone with an atmosphere with low pollution?<br>Are you in a space with moderate frequency of condensation & moderate pollution from production process, e.g. food-processing plants, laundries, breweries, dairies? | Yes → | **Medium Corrosivity C3** |

**No ↓**

| | | |
|---|---|---|
| Are you in a temperate zone with an atmospheric environment with low pollution ($SO_2$ < 5 µg/$m^3$), e.g. rural areas, small towns?<br>Are you in a dry zone with an atmospheric environment with short time of wetness, e.g. desert areas?<br>Are you in an unheated & un-air-conditioned space with varying temperature & relative humidity with low frequency of condensation & low pollution, e.g. storage rooms or buildings, sport halls? | Yes → | **Low Corrosivity C2** |

**No ↓**

| | | |
|---|---|---|
| Are you in a dry zone with an atmospheric environment with very low pollution & time of wetness, e.g. certain deserts?<br>Are you in a dry, continually heated or air-conditioned space with low relative humidity & insignificant pollution, e.g. offices, schools, museums? | Yes → | **Very Low Corrosivity C1** |

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# Micro Environments

The micro-environment around a structure has consistently been shown to be an important element in the corrosion of metals. In many cases, the micro-environment can be influenced by design factors, while in other cases it can be influenced by external factors such as industrial processes.

Identifying the prevailing conditions around the location of the article to be galvanized prior to finalising the design is critical in achieving the long-term durability of a structure. For example, the underside of a bridge, which is stretched over a body of water, will have a micro environment that is likely to differ from the general environment of the bridge.

### Shelter from Rain and Regular Washing

Corrosion rates may increase significantly above the values shown in the chart due to the micro environment (the site and local conditions prevailing around the structure), such as severe coastal locations where the surface is exposed to high levels of airborne salinity, but not subjected to the cleansing influence of rainwater. Research shows that this can increase corrosion rates in the sheltered areas by three to five times those experienced in the washed areas of the same structure. This issue is not confined to galvanized coatings and designers should consider this aspect early on in the design phase.

Where the steelwork is partially sheltered (such as inside sheds with large openings and under the eaves of domestic buildings), it is recommended the specifier assume these are considered as part of the external environment. Another example of this is in the design of lintels for domestic buildings using masonry construction, where the Building Code specifies hot dip galvanized sections.

In some instances, where the micro-environment is significantly more severe than for the rest of the structure, the area may best be provided with a duplex coat to provide additional protection in the areas subject to the micro-environment. Special consideration is often required for buildings containing chemical, humid, or contaminated environments to achieve the required design life. The GAA can provide general guidance on particular chemical pollutants.

### Prolonged Surface Wetness (Ponding)

Galvanized steel should not sit in ponding water – generally, this will result in accelerated corrosion.

In the design of structures with concrete pads for columns, the use of epoxy paints or protective wraps over the top of the galvanized coating around the embedded area is a well understood feature and can result in a practical life equal to the design life.

### Abrasion and Erosion

Hot dip galvanized steel provides considerably more abrasion protection than bare steel and painted steel structures. Even so, the designer should consider the particular micro environment to understand what affect, if any, it will have on the life of the galvanized structure.

Other micro environments include articles buried or in long-term contact with soils, immersed in or splashed by fresh or salt water, contact with wood and bimetallic corrosion. Advice on these exposures is also available from the GAA.

*Continued overleaf*

*Continued*

# Determining the Environment

In general, the specifier should answer the following questions:

a) What is the nature of the macro environment?
b) Are there significant micro environments that need to be assessed?
c) Is the environment likely to change?
d) Are there multiple environments within the structure that will affect the overall life to first maintenance of the structure?

AS 4312 provides maps of key population areas of Australia to assist in general determinations.

### Summary

The atmospheric corrosion rate of hot dip galvanized articles is predictable and offers considerable benefits to the specifier over uncoated steels. In many cases, it is essential to provide corrosion protection for the steel in order to meet the design life of a structure and in most cases hot dip galvanizing provides an economical and attractive solution.

A designer must take into account the location of the finished article, which requires a consideration of the regional or macro environment, the site and local or micro environments around the location as well as an understanding as to whether the environment will change over time.

Hot dip galvanized articles have performed successfully in the Australian environment for many years and their durability is well understood. Numerous structures have performed for over 50 years, with documented cases of products lasting over 100 years.

### References:

**ISO 9223**, Corrosion of metals and alloys – Corrosivity of atmospheres – Classification

**ISO 14713-1**, Zinc coatings – Guidelines and recommendations for the protection against corrosion of iron and steel in structures – Part 1: General principles of design and corrosion resistance

**AS 4312**, Atmospheric corrosivity zones in Australia

**AS/NZS 2312**, Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings

**AS/NZS 4680**, Hot-dip galvanized (zinc) coatings on fabricated ferrous articles.

**Housing in Brisbane.**

More than 1km from the coast, this is typically a C2 zone and the galvanizing will receive regular rain washing, meaning the micro environmental effects will be reduced.