Atmospheric corrosivity classification

Knowing the degree of corrosion risk in a particular environment is the key to specifying metals and protective measures that will be durable in that environment. There are both international and New Zealand classifications of atmospheric corrosivity. This BRANZ Facts gives an outline of the most important ones used today.

ATMOSPHERIC CORROSION of metal requires the presence of moisture and oxygen. Salts such as chlorides in sea salt or sulphur-containing gases in geothermal and/or industrial areas can dissolve in the moisture on a metal surface and significantly increase the rate of corrosion. This is part of the reason why some atmospheres – such as those close to breaking surf beaches – are more corrosive than others.

New Zealand Building Code clause B2 *Durability* requires that materials will remain functional for certain minimum periods:

- 50 years for building elements that provide structural stability or are difficult to access or replace or where failure may go undetected.
- 15 years for building elements that are moderately difficult to access or replace or where failure would go undetected during normal use but would be easily detected during normal maintenance.
- 5 years for building elements that are easy to access and replace and where failure would be easily detected during normal use.

Corrosion can obviously threaten these durability requirements. The New Zealand Building Code, Acceptable Solutions and New Zealand standards take considerable account of the risks of corrosion. Considering the classification of atmospheric corrosivity plays a big part in selecting and specifying the appropriate materials and protective measures.

Manufacturers of building products sold in New Zealand may refer to specific exposure zones as defined by relevant New Zealand standards when indicating the environments where they recommend the use of their products or they may use international classification systems. One profiled sheet metal manufacturer, for example, uses categories from the international standard ISO 9223:2012 *Corrosion of metals and alloys – Corrosivity of atmospheres – Classification, determination and estimation* for its products. It recommends that one of its claddings can be used for roofing in a severe coastal environment (because the whole surface will receive rain washing) but not for wall cladding.

International classification

ISO 9223:2012 established a system for classifying the corrosivity of atmospheric environments. Specifically, it defines atmospheric corrosivity categories by using the first-year corrosion rate of standard metals, including carbon steel, zinc, copper and aluminium. Six corrosivity categories have been identified:

- C1 – very low
- C2 – low
- C3 – medium
- C4 – high
- C5 – very high
- CX – extreme.

New Zealand's corrosivity classifications

There are a number of corrosivity classifications in New Zealand (Table 1). The key standards and technical specifications to be aware of are:

- NZS 3604:2011 *Timber-framed buildings*
- AS/NZS 2312.1:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 1: Paint coatings*
- AS/NZS 2312.2:2014 *Guide to the protection of structural steel against atmospheric corrosion by the use of protective coatings – Part 2: Hot dip galvanizing*
- AS/NZS 2728:2013 *Prefinished/ prepainted sheet metal products for interior/exterior building applications – Performance requirements*
- SNZ TS 3404:2018 *Durability requirements for steel structures and components*.

NZS 3604:2011 plays a key role in durability in house construction. It contains maps that divide New Zealand into exposure zones B, C and D, depending on exposure to wind-driven sea salt (Figure 1). Zone B is the least exposed and zone D the most. Zone D includes all areas within 500 m of the coast including harbours, 100 m from tidal estuaries and sheltered inlets, all offshore islands and all other areas shown in white in the map. (The exposure zones are also given in the BRANZ Maps online tool.)

The classifications were largely determined from BRANZ research. From the late 1980s, BRANZ measured the corrosion rates of various metals (mild steel, hot-dip galvanised steel and aluminium) at 168 locations across the country.

As an example of the results, corrosion rates of mild steel after 1 year of exposure varied from 18–4,800 g/m^2/year. The highest rates were in geothermal areas. There was also a clear link between corrosion rate and distance from the coast.

The maps in NZS 3604:2011 allow designers to understand the atmospheric corrosivity of a particular location. From this, they can select the zone they are working in and specify the appropriate materials.

Acceptable Solution E2/AS1 has a zone E (severe marine – breaking surf beach fronts) for material selection in Table 20. The corrosion protection requirements for structural fixings in zones D and E are the same, so zone E does not appear in NZS 3604:2011. (Zone E in E2/AS1 is also effectively the same as atmospheric corrosivity category E in AS/NZS 2728:2013)

In the 2010s, BRANZ measured the first-year atmospheric corrosion rates of mild steel and hot-dip galvanised steel samples at 61 sites. Most of them were located in the Auckland, Wellington, Christchurch and Dunedin regions.

At most testing sites, the newly derived atmospheric corrosion data was comparable with the old data collected in the 1980s, which produced the NZS 3604:2011 maps. At a limited number of testing sites, however – such as Auckland Airport, Tiwai Point and Greymouth – significant changes were seen in corrosion rates of mild steel and/or hot-dip galvanised steel samples. This indicated that the atmospheric corrosivity in some areas was changing.

Comparisons between atmospheric corrosion categories determined by the new data and by the current New Zealand atmospheric corrosivity map indicated that it was necessary to adjust zone boundaries in some areas within Auckland, Wellington, Christchurch and Dunedin. This led to the production of four updated regional atmospheric corrosivity maps. Details around this study can be found in BRANZ Study Report SR288 *Update of New Zealand's atmospheric corrosivity map* and SR325 *Update of New Zealand's atmospheric corrosivity map (Part 2)*.

BRANZ research from 2016–2018 (BRANZ Study Report SR458) suggests that several other amendments should also be made to what is set out in NZS 3604:2011.

- In areas with some level of geothermal/ industrial influences, including mainly Rotorua, Tikitere, Rotomā, Kawerau, Te Teko and Edgecumbe, the atmospheric corrosivity category should be increased to from zone B to zone C. A map of the proposed changes appears as Figure 9 in BRANZ Study Report SR458.
- Currently, the standard requires specific engineering design for buildings constructed within 50 m of a geothermal hot spot. It would be appropriate to increase the current boundary from 50 m to 500 m. This would also bring it into alignment with SNZ TS 3404:2018.

AS/NZS 2312:2014 outlines the use of paint coatings (Part 1) and hot-dip galvanising (Part 2) to protect steel from atmospheric corrosion with its own classifications. It includes C1, C2, C3, C4, C5 and CX as defined by ISO 9223:2012 and an inland tropical category referred as T (AS/NZS 2312.1:2014).

AS/NZS 2728:2013 also gives atmospheric environments. These product types are referenced in many documents from manufacturers of metal roof and wall claddings.

Some building product manufacturers have prepared product selection guides based on these classifications. One paint manufacturer, for example, describes the likely durability of its coatings based on these corrosivity categories. Products with a durability of 10–15 years in the medium category may only have durability of 2–5 years in the very high industrial or marine categories.

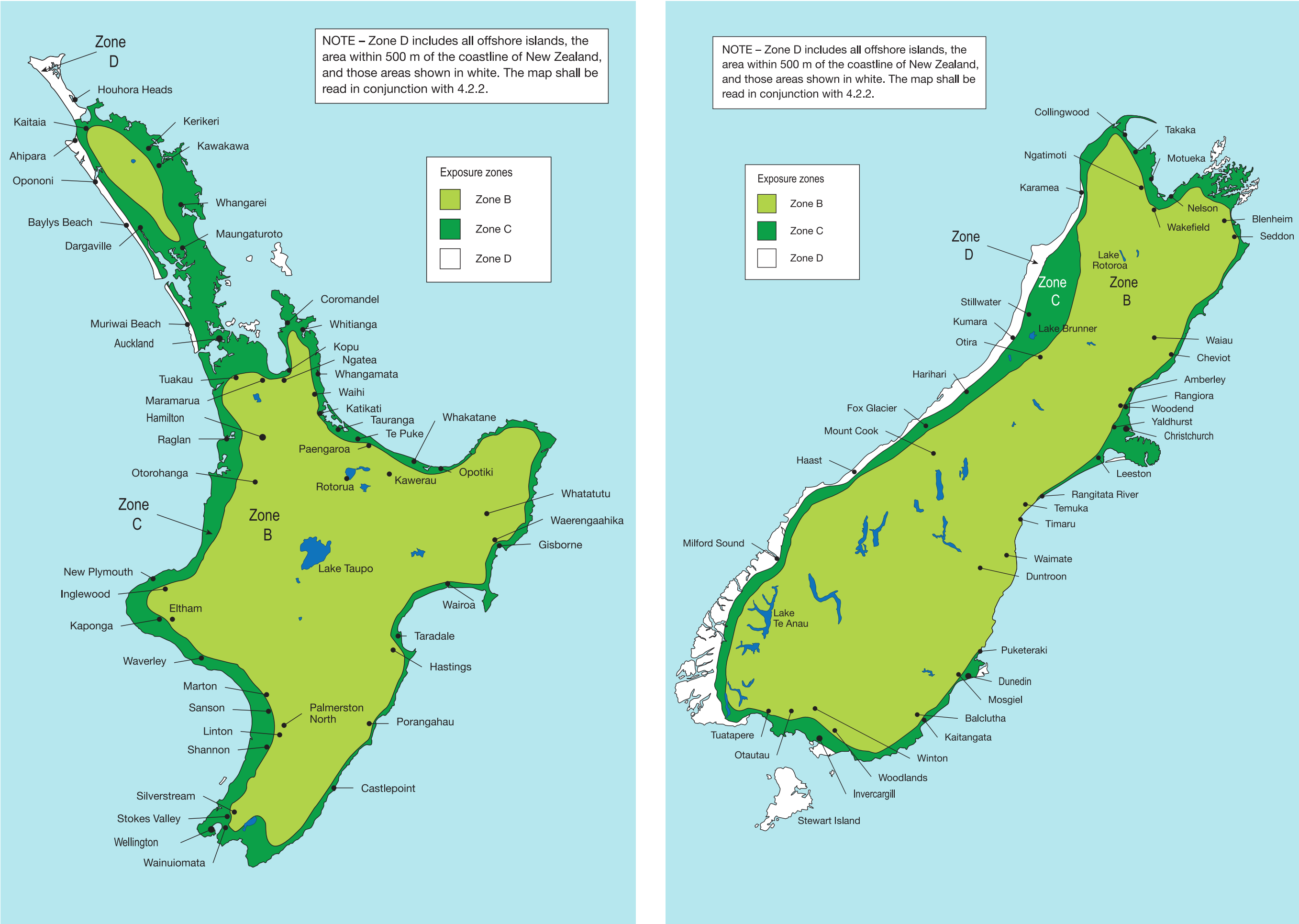

Figure 1. Exposure zone maps in NZS 3604:2011.

SNZ TS 3404:2018 refers to the corrosivity environments given in ISO 9223:2012 and also includes corrosivity maps of New Zealand. This map was developed by using the first-year macro-climate corrosion rates of carbon steel at different sites in New Zealand. The corrosion rate was calculated using six equations that are a function of critical meteorological variables.

There are other corrosivity classifications for specific building materials or elements. For example, there are environmental exposure classifications in NZS 3101.1&2:2006 *Concrete structures standard*. These allow designers and engineers to ensure durability of concrete by accounting for wet or salty conditions, aggressive soil or groundwater or contact with potentially aggressive chemicals.

Table 1. Comparison of atmospheric corrosivity classifications.

ISO 9223:2012	AS/NZS 2728:2013	AS/NZS 2312.1:2014	AS/NZS 2312.2:2014	NZS 3604:2011	E2/AS1	Description
C1	1	C1	C1			Very low
C2	2	C2	C2	B	B	Low
C3	3	C3	C3	C	C	Medium
C4	4	C4	C4	D****	D	High
C5	5* and 6**	C5	C5		E	Very high
CX		CX	CX			Extreme
		T***				

* Very high – industrial.
** Very high – marine and geothermal.
*** Corrosivity in inland tropical regions is generally similar to C2. However, its corrosivity towards organic coatings means durability is lower than for the C2 category.
**** Corrosion protections for structural fixings in D and E are identical, therefore only D is included in NZS 3604:2011.

Atmospheric corrosivity determination

The simplest approach for evaluating atmospheric corrosivity is by exposing clean, flat metallic plates of standard dimensions and surface finishes to an atmosphere of concern and recording their weight losses over time. The most commonly used metals include mild steel (or low-carbon steel), zinc, copper and aluminium. Corrosion rates measured after 1 year are used to classify atmospheric corrosivity category according to ISO 9223:2012. Meanwhile, the corrosion rates after longer exposure periods provide information about the protective character of the layer of corrosion products developed and are therefore more reliable for long-term durability evaluation.

Another technique is the CLIMAT (CLassify Industrial and Marine ATmospheres) test, also known as the wire-on-bolt test. This method uses a helical coil of material wrapped around a coarsely threaded bolt to offer a high surface area ratio and a much higher sensitivity to atmospheric corrosion when compared with a flat metallic plate. Exposure times can be significantly reduced, typically to 3 months. The percentage weight loss of the wire is commonly expressed as the corrosion index. Five levels (negligible, moderate, moderately severe, severe and very severe) are commonly defined. The CLIMAT method only provides comparative corrosivity information and an indication of relative atmospheric corrosion severity.

Atmospheric corrosivity can be estimated based on calculated first-year corrosion rates. In ISO 9223:2012, dose-response functions have been given for carbon steel, zinc, copper and aluminium. With these functions, the first-year metal atmospheric corrosion rate can be calculated by inputting critical environmental parameters. These include annual average values of sulphur dioxide (SO_2) deposition, chloride (Cl^-) deposition, ambient temperature (T) and relative humidity (RH).

Additionally, ISO 9223:2012 gives an informative atmospheric corrosivity estimation with a qualitative description of environments (see Table C.1 *Description of typical atmospheric environments related to the estimation of corrosivity categories*).

Conclusion

There are both international and New Zealand classifications of atmospheric corrosivity.

One of the most widely used classification systems in the New Zealand building and construction industry is the exposure zones given in NZS 3604:2011. In these maps, New Zealand is divided into exposure zones B, C and D, depending on exposure to wind-driven sea salt. There are other local standards with categories relevant to steel and sheet metallic building products.

One of the most important international standards is ISO 9223:2012. There is a reasonably good and consistent correlation between the corrosivity categories defined by the relevant national and international standards.

Knowing the degree of corrosion risk in a particular environment is the key to specifying metals and their protective measures that will meet New Zealand Building Code durability requirements in that environment.

Further reading

BRANZ Facts: Metal corrosion in New Zealand buildings #1 *Corrosion in coastal buildings*

BRANZ Facts: Metal corrosion in New Zealand buildings #2 *How metals interact in the built environment*

BRANZ Facts: Metal corrosion in New Zealand buildings #3 *Corrosion over the building envelope*

BRANZ Facts: Metal corrosion in New Zealand buildings #4 *Corrosion of metal in timber and concrete*

BRANZ Facts: Metal corrosion in New Zealand buildings #6 *How metals are protected against corrosion*

BRANZ Research Now: Positional corrosion #1 *The impacts of natural elements on different parts of the building envelope*

BRANZ Research Now: Positional corrosion #2 *How different micro-environments around a building envelope affect material corrosion*

BRANZ Bulletin 649 *Corrosion of metals in New Zealand buildings*

BRANZ Bulletin 631 *How micro-environments affect material performance*

BRANZ Bulletin 574 *Preventing corrosion of reinforcing steel in concrete*

BRANZ Study Report SR288 *Update of New Zealand's atmospheric corrosivity map*

BRANZ Study Report SR325 *Update of New Zealand's atmospheric corrosivity map (Part 2)*

BRANZ Study Report SR458 *Atmospheric corrosivity of the Bay of Plenty region*