

or other insulating material between the dissimilar metals.

The concept of sacrificial protection is harnessed to provide cathodic protection to structures subjected to severe corrosive conditions such as immersion in aggressive water or corrosive soils. Zinc or magnesium anodes are attached to steel components to provide protection to the steel. These sacrificial anodes are replaced once they have been consumed.

Crevice corrosion can occur in conditions of high humidity at overlapping hot dip galvanized surfaces. This can be prevented by the application of an inhibitive jointing compound in accordance with SANS 1305. Alternatively a suitable paint may be used. Hot dip galvanized surfaces in contact with other materials also require insulation.

Hot dip galvanized components in contact with aluminium conductors may require the use of an electrical conducting compound at joint faces to repel moisture and inhibit corrosion.

12.5 CORROSION RESISTANCE OF HOT DIP GALVANIZED COATINGS IN AQUEOUS CONDITIONS

General

Zinc carbonate, the protective film formed over a hot dip galvanized coating, is relatively insoluble in water. However, this stability is restricted to an acid/alkali pH range of 6 to 12.5. Zinc is amphoteric in nature; that is, it forms soluble salts at low and high pH values. This is clearly shown in figure 96.

Notwithstanding the above, water contains numerous dissolved salts as well as

carbon dioxide and oxygen in solution. Organic matter can be picked up by water as it passes over vegetation. This can also be a major contributor to corrosion in some instances. The effects of water quality on the corrosion rate are summarized in figure 97.

In soft waters, zinc corrosion is accelerated. Also, the tolerance for chloride salts is reduced. A reserve alkalinity level is required to stabilize the zinc carbonate film. This is generally assumed to be of the order of 50 - 75mg/l (as CaCO₃). In hard waters, high chloride levels (>2000mg/l) can be tolerated. Sulphates, nitrates and phosphates are generally considered to be protective towards hot dip galvanizing. However, when combined with ammonia compounds (such as with fertilizers) soluble zinc compounds may be formed and acid conditions can arise causing attack of hot dip galvanized steel. Organic compounds such as tannins will arrest the corrosion of hot dip galvanized steel but the settling of solids can create conditions for crevice corrosion. Similarly, slime build-up should be avoided as microbially induced corrosion (MIC) can occur, leading to rapid attack.

Flow rates should be maintained at sufficiently high levels to ensure that all debris is held in suspension rather than allowed to settle. It should be considered "good practice" to flush systems on a regular basis. This should be carried out on all fire protection systems although, as the water entering these systems is generally of good quality, corrosion rates tend to be low provided that MIC does not occur. In all instances, the corrosion performance of galvanized piping in fire protection sys-

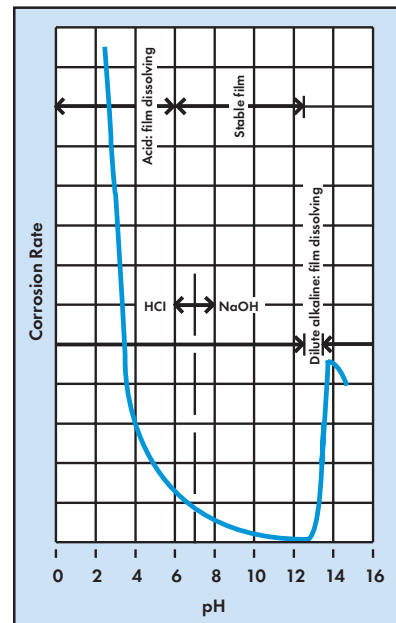


Figure 96. The influence of pH on the corrosion rate of zinc in aerated (CO₂ free) solutions. (Dilute HCl and NaOH at 30°C).
Note: The curve only applies for continuous exposure under the specific conditions. For other conditions it can be used as a guide. In hard/scale forming waters protective layers are formed which greatly alter the curve.

tems is far superior to that of bare steel. Crevice or under deposit corrosion is likely to occur where sediment becomes dense and compacted. This may result in the provision of anaerobic sites suitable for the start of MIC.

Under normal circumstances the amount of dissolved oxygen in a water would be sufficient to ensure that no deleterious effects occur. However, anaerobic or septic conditions can affect hot dip galvanized piping adversely as is the case with other metals. For drinking water purposes some form of chlorination is generally applied. Therefore, in normal distribution systems anaerobic conditions giving rise to MIC, should not occur. It is important when testing water lines that clean water be used **and the system drained if it is to be left unused for some time.** Chlorination has no effect upon the protective properties of galvanizing. High oxygen levels accelerate the corrosion rate of zinc. Similarly, high carbon dioxide levels tend to produce acid conditions, which can accelerate corrosion in flowing systems.

Effect of water temperature

Hot dip galvanized piping has been used for hot water supplies with no deleterious effects in many applications. However, when used above 65°C the zinc is no longer protective to exposed steel. It is therefore recom-

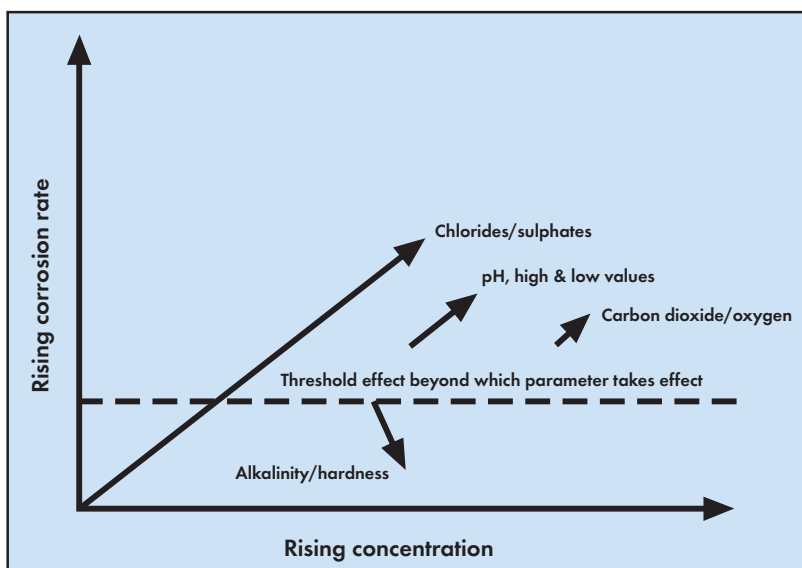


Figure 97. Effects of water quality on the corrosion rate of a hot dip galvanized coating.

No.	Aggressiveness	Soil Condition	Resistivity in ohm	Method of protection
1	low	dry	>100	Hot dip galvanizing > 200µm
2	low	moist	>450	Hot dip galvanizing > 200µm
3	moderate	dry	<100	Hot dip galvanizing > 200µm plus a rust allowance on the basis material of 0.5mm on each side.
4	moderate	moist	150-450	Same as for 3
5	high	moist	50-150	Hot dip galvanizing > 200µm and rust allowance of 1 mm on each side.
6	very high	moist (In certain cases H ₂ SO ₄ can form)	<50-100	Same as for 5 but rust allowance of 1.5mm on each side

Table 25. Soil aggressiveness at different resistivity levels with hot dip galvanized coatings.

mended that hot dip galvanized systems not be used above 65°C.

The electricity supply commission (Eskom), advise that with proper pipe insulation, the maximum temperature for hot water cylinders be 60°C. For practical purposes therefore, hot dip galvanized piping is acceptable for use in both hot and cold water systems.

In domestic systems copper should only be used downstream of hot dip galvanized piping. This will avoid the possibility of pitting corrosion.

Effect of sea water

Hot dip galvanized coatings perform relatively well in submerged seawater conditions which are severely corrosive to most protective systems. Dissolved salts present in seawater react with zinc to form a protective layer minimizing corrosive action. The pH of seawater tends to be constant worldwide as a result of the buffering action of the hydrogen-carbonate salts present. The presence of pollutants is equally not detrimental provided that levels are within internationally acceptable norms.

A simple nomogram (table 27) has been produced to allow the specifier to determine the suitability of hot dip galvanizing for the protection of steel piping in water. This provides guidance based upon the water quality and general operating conditions likely to be encountered. More detailed information is contained in **ARP 060: Guidance on the use and application of hot dip galvanized steel piping for the transportation of potable water in South Africa.**

12.6 CORROSION RESISTANCE OF HOT DIP GALVANIZED COATINGS IN SOIL CONDITIONS

Soil can contain weathered products, free or bound salts, acids and alkalis,

mixtures of organic substances, oxidizing or reducing fungi, micro-organisms, etc.. Depending on its structure, soil has different degrees of permeability to air and moisture. Normally, the oxygen content is less than in the air, while the carbon dioxide content is higher. The corrosion conditions in soil are therefore very complicated and variations can be great between different locations, even those in close proximity to each other.

Southern African soils vary from highly corrosive in some regions to moderately corrosive in others.

One method of determining the corrosivity of a soil is to measure its resistivity. Recommendations are given in table 25.

If the resistivity of the soil cannot be determined, the rule-of-thumb method listed in table 26 can give a measure of guidance. Where the exposure of metals to soil is concerned, it is advisable to seek expert advice from suitably qualified sources.

See also "Guidelines for Buried Hot Dip Galvanized Conveyance Piping" – available from the Association.

12.7 HOT DIP GALVANIZED STEEL IN CONTACT WITH BUILDING MATERIALS

Mortar, Plaster and Wood

Damp mortar and plaster attack zinc. The attack ceases when the material dries out. Dry or moderately damp wood, both impregnated and unimpregnated, can be nailed with hot dip galvanized nails to good effect. However, in the case of nails or threaded unions that are constantly exposed to water an acid-resistant material is preferred. Other dry building materials, such as mineral wool, do not attack zinc.

Wood with acidic properties should not come into contact with galvanized steel.

Soil type	Aggressiveness
Lime, calcareous marl, moraine, sand marl	Low
Sand, gravel	Moderate
Clay, peat, bog, humus-rich soils	High

Table 26. Corrosivity of different soil types.

VALUE	PARAMETER	UNIT	RATING
CONDITION OF WATER			
A	Flowing		2
	Standing		1
	Anaerobic		-5
CORROSION INDEX *			
B	<1		0
	≥1, <2		-1
	≥2, <5		-2
	≥5		-4
TOTAL ALKALINITY			
C	<50	ppm as (CaCo3)	-1
	≥50, <200		1
	≥200, ≤300		0
	>300		-1
CALCIUM HARDNESS			
D	<50	ppm as (CaCo3)	-1
	≥50, <200		2
	≥200		3
pH			
E	<5.5		-6
	≥5.5, <6.5		-4
	≥6.5, ≤7		-1
	>7		1
CALCIUM CARBONATE PRECIPITATION INDEX			
F	<-2		-2
	≥-2, <0		-1
	0		0
	>0, ≤6		1
	>6		0
Probability = Sum (A to F)			
Result	Performance		
Greater than 1	Satisfactory (+25 years)		
1 to -1	Fair		
-3 to -5	Unsatisfactory		
* Corrosivity index (B) can be calculated by - (C1 x 0,03) + (SO ₄ x 0,04)			

Table 27. Probability of performance.

Concrete

Unprotected reinforcement can corrode in certain environments when moisture penetrates the concrete through cracks and pores. Since rust has a greater volume than the steel from which it was formed, the covering layer over the reinforcement can crack and spall (figure 99).

Steel components such as bolts and edge guards that have been partly grouted in are often poorly protected against rust. Apart from crack formation and scaling, a problem occurs with unsightly rust staining on the concrete surfaces below.