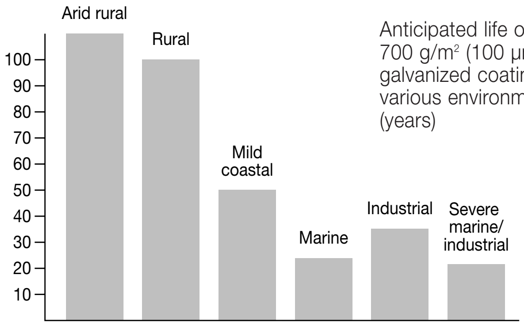
the extremely corrosive conditions of heavy industrial areas it is desirable to reinforce galvanized coatings with a paint system resistant to prevailing conditions.

In these severely corrosive conditions galvanized coatings in combination with suitable paint systems provide longer, more economic life than the best alternative systems. Suitable paint systems and application techniques are described in the section 'Painting galvanized steel'.



Anticipated life of 700 g/m² (100 µm) galvanized coatings in various environments (years)

Effect of temperature

Hot dip galvanized coatings should not be used in applications where temperatures continuously exceed 200°C, as prolonged exposure to these temperatures will lead eventually to detachment of the coating from the base steel.

Under water

General. The corrosion rate of zinc under immersed conditions can be high in acidic solutions below pH 6 and alkaline solutions above pH 12.5. Between these limits the rate of corrosion is much lower.

In mains supply water of pH 6 to pH 8, calcium carbonate is normally present and this is precipitated onto the galvanized coating as an adherent calcium carbonate scale, together with zinc corrosion products, forming an impervious layer. When sufficiently dense, this layer virtually stops corrosion of the coating, resulting in very long life in many domestic water systems.

Other factors may interfere with this scale deposition. If the water has a high concentration of uncombined carbon dioxide, the protective scale is not formed and full protection never develops. The characteristics of the water supply should be taken into account in the design of domestic water systems. The presence of even small quantities of dissolved copper of the order of 0.1 parts per million in the water may cause corrosion by rapid pitting as discussed under galvanic corrosion page 22.

In unfavourable waters galvanized steel may require the added protection of galvanic anodes or suitable paint coatings.

Pure water. When newly galvanized articles are immersed in pure water such as rainwater there are no dissolved salts present to form the film of insoluble compounds which normally protects the coating from further action. Where practical this condition can be corrected by the addition to the water of controlled amounts of salts during initial immersion.

Most natural waters contain sufficient dissolved salts to prevent initial attack and galvanized tanks and equipment give excellent service.

Effect of water temperature. In cold water of normal composition galvanized coatings are most effective and the rate of consumption of the coating is very low. This has resulted in almost universal use of galvanized steel for tanks for water storage and transport.

At about 60°C to 65°C the rate of corrosion of galvanized coatings increases and continued corrosion resistance depends on early formation of adequate non-flaking scale. Hard water in hot water systems will deposit a scale of calcium and magnesium carbonates on the galvanized surface, nullifying the temperature effect. Soft water may not deposit a protective scale. In such cases galvanized coatings are unsuitable for hot water systems.

Sea water. Galvanized coatings perform relatively well in submerged sea water conditions which are severely corrosive to most protective systems. Dissolved salts present in sea water react with zinc to form a protective layer minimising corrosive action.

The addition to the galvanized coating of a suitable paint system is recommended in areas of severe sea water exposure, particularly in the splash zone. Such duplex systems provide the best available protective coating for steel in sea water. Suitable paint coating systems are listed in table 3, page 69.

Underground

The corrosion behaviour of buried galvanized steel varies greatly with the type of soil. Knowledge of local conditions is therefore essential in estimating the life of galvanized steel pipes. Generally galvanized steel lasts considerably longer than uncoated or painted steels but performance is best in alkaline and oxidising soils, where a 600 g/m² galvanized coating will give an additional life of about 10 years to steel pipes. Highly reducing soil is most aggressive and may consume zinc coatings at more than 13 µm per year.

The life of galvanized steel underground is extended by the use of paint coatings, bituminous compounds, tape wraps or concrete encasement.

In contact with chemicals

Galvanized coatings are highly resistant to attack over a wide pH range, particularly in moderately alkaline solutions as shown in the diagram below. Unprotected galvanized coatings should not be used with acid solutions below pH 6 or alkaline solutions above pH 12.5.

At intermediate values between these limits a protective film is formed on the zinc surface and the coating corrodes very slowly. Since this range covers most types of water and all but the strongest alkalis, galvanized coatings have wide application for storing and conveying liquids.

Most organic liquids, other than those acid, attack zinc only slightly and galvanized coatings are suitable for storage tanks and equipment for handling a wide range of organic chemicals, including motor fuels, creosotes, phenols and esters.

Galvanized coatings are used in refrigeration equipment circulating brine solutions treated with sodium dichromate inhibitor.

Effect of pH on corrosion rate of zinc. In the range pH 6 to pH 12.5 the zinc coating forms a stable protective film and corrosion rate is low.