

Figure 89. In order to avoid the formation of wet storage stain on newly galvanized surfaces, profiled steel, beams and structures should be packed at an angle and turned to prevent the accumulation of water. Spacers are placed so as to avoid narrow crevices between the zinc surfaces.

Electro-positive end - more noble metals	↑	Gold
		Silver
		Stainless steel (304)
		Nickel
		Monel
		Aluminium bronze (95% Cu, 5% Al)
		Copper
		Brass
		Tin
		Lead
Electro-negative end - more reactive metals	↓	CAST IRON, unalloyed
		CARBON STEEL
		Cadmium
		Aluminium
		ZINC
		Magnesium

Table 24. Electrochemical potential scale in sea water at +25°C.



Figure 90. Galvanized bolt in contact with 3CR12 plate after 10 cycle SO<sub>2</sub> test. Note the cathodic protection provided by the galvanized bolt head to the surrounding steel.

shiny surfaces and particularly between closely packed sheets, angles and similar products. A pre-requisite is that the material is exposed to condensate or rain water in conditions where the moisture cannot evaporate quickly. Zinc surfaces that have already formed a normal protective layer of conversion products are seldom attacked.

When freshly galvanized surfaces are exposed to the atmosphere, soluble zinc oxide and zinc hydroxide are formed. Under the influence of carbon dioxide in the air basic zinc carbonate is formed. If air access to the zinc surface is restricted, as in narrow crevices, then the area receives insufficient carbon dioxide to enable the normal layer of zinc carbonate to form.

The wet storage stain deposit is voluminous and porous, and attached only loosely to the zinc surface. As a result, protection against continued attack does not exist. Corrosion can therefore continue as long as moisture remains on the surfaces. When wet storage stain has occurred the object should be re-stacked to enable the surfaces to dry quickly. This will stop the attack and, with free access to air, the normal protective layer will be formed. The wet storage stain is gradually washed away and the coating acquires an appearance that is normal for exposed, hot dip galvanized steel.

Since the product of wet storage stain is very bulky (about 4.5 times the solid volume of zinc from which it is formed), an attack can appear to be serious.

Sometimes when discolouration is severe it is natural to conclude that rust protection has been greatly reduced, or completely destroyed. However, this is seldom the case. The iron/zinc alloys give better protection (in most environments up to 30-40% greater) to the underlying steel than pure zinc.

If appearance is important, discoloured surfaces can be painted (figures 30, 31 and 87).

### 12.3 WET STORAGE STAIN

Sometimes a white, flourey and voluminous deposit called wet storage stain, or white rust, appears on galvanized surfaces (figure 88).

The deposit forms on freshly galvanized,

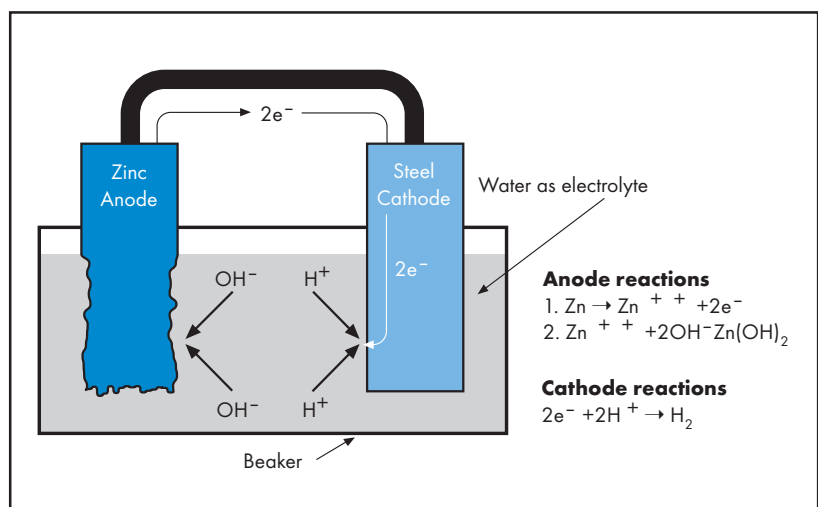


Figure 91. Galvanic corrosion of zinc in contact with steel in water.



Figure 92. After 20 years of marine exposure, this site cut unrepaired hot dip galvanized steel grating still offers cathodic protection at the cut ends.

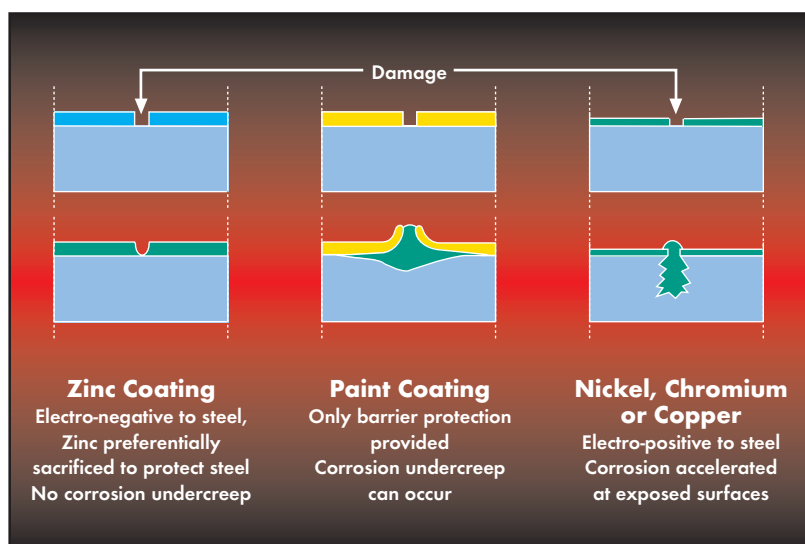


Figure 93. Schematic diagram to illustrate the consequences of damage to different types of coatings offering corrosion protection.

However, wet storage stain often has little or no significant impact on the service life of the coating but in the case of very thin coatings a severe attack of wet storage stain can be significant.

Wet storage stain is best avoided by preventing closely packed galvanized surfaces from coming into contact with rain or condensate. Freshly galvanized material which is exposed to the elements should be stacked in a manner that ensures free air circulation (figure 89). Temporary protection against wet-storage stain is obtained through chromating or phosphating.

Wet storage stain which has already formed can be removed completely or partially by moderate mechanical or

chemical treatment. See "Removal of Wet Storage Stain" page 17.

#### 12.4 GALVANIC OR BIMETALLIC CORROSION

Corrosion can be defined as an electrochemical process. Galvanic or bimetallic corrosion occurs when two different metals or alloys in the presence of an electrolyte, are in direct electrical contact with each other. Basic corrosion theory states that for corrosion to take place, there are four essential requirements, i.e. an anode, a cathode, an electrolyte and an electrical circuit. If one of these is absent, corrosion ceases. Different metals possess different electrochemical potentials as shown in Table 24. The electronegative and more reactive met-



Figure 94. Stainless steel fasteners attached to hot dip galvanized plate in immersed conditions, note the sacrificial attack of the zinc coating surrounding uninsulated fasteners compared with the insulated fastener where no attack of the surrounding zinc has taken place.

als will corrode in preference to a more electropositive metal when the two are in direct electrical contact, i.e. the anode is attacked whereas the cathode is protected. The electrical potential scale of some metals may vary, depending on the electrolyte but the information contained in table 24 which relates to sea water is typical for most liquids.

If steel is in direct contact with copper or brass, it constitutes the anode and it will be preferentially attacked. On the other hand, if steel is coupled to cadmium, aluminium, zinc or magnesium, it will constitute the cathode and be protected, while the anodic material is consumed.

A hot dip galvanized coating primarily provides barrier protection since in most environments it corrodes at a substantially slower rate than steel. The second line of defense is however the cathodic or sacrificial protection at small uncoated surfaces which is provided by the electronegative potential of zinc in relation to carbon steel.

The impact of bimetallic corrosion can be prevented by the provision of a paint

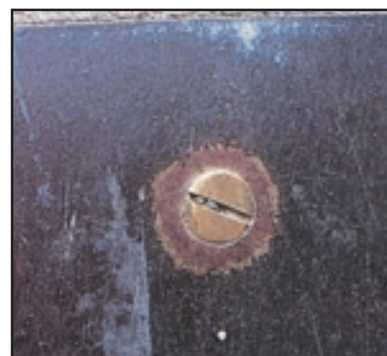


Figure 95. Brass bolt in hot dip galvanized steel on a parking deck.