The corrosion protection of hot dip galvanizing (zinc) results from the formation of a dense insoluble "barrier protection" layer of zinc carbonate on the surface of the hot dip galvanized (zinc) coating. Depending on the steel's chemical composition, particularly the amount of silicon and phosphorous, newly galvanized steel will have surface finishes ranging from a bright shiny finish to a dull grey matt colour.

Initially "new" zinc surfaces oxidise to an unstable water soluble zinc oxide (ZnO), zinc hydroxide ($Zn(OH)_2$), (depending on the moisture content of the atmosphere), and finally to an insoluble dense zinc carbonate ($ZnCO_3$) layer.

The first two products of corrosion, (ZnO & $Zn(OH)_2$) are unstable and easily removed. The $ZnCO_3$ layer, by contrast, is stable, not easily removed, matt grey in colour and it is this stable layer that forms the required "Barrier Protection" for corrosion control.

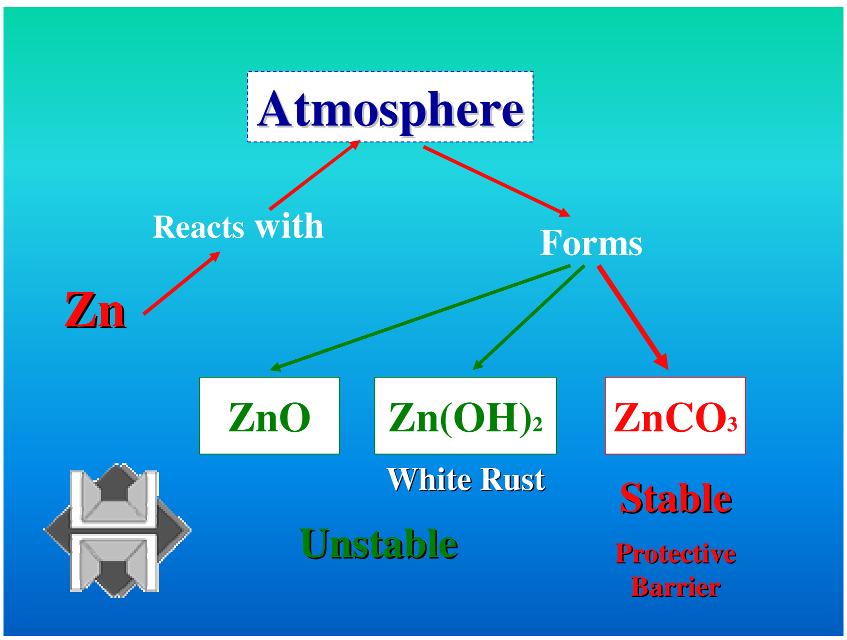

Fig 1: Chemical reaction of pure zinc with the atmosphere, being Oxygen, Moisture and Carbon Dioxide. Products of corrosion formed, are zinc oxide, zinc hydroxide and zinc carbonate.

It is, therefore, of paramount importance that a freshly galvanized surface is allowed to "weather" and form its zinc carbonate barrier protection. Although the $ZnCO_3$ is slowly removed, it is continually being replaced by the remaining underlying zinc and zinc iron alloys. Corrosion control is active as long as zinc is present on the steel surface. Zinc is therefore referred to as a wasting material. The zinc carbonate layer corrodes very slowly and at a rate which is dependant on the environment in which the zinc coated steel is required to operate. It follows, therefore that the thicker the zinc coating the longer the resulting service life and corrosion control achieved in protecting the carbon steel component.

Should a "small" exposed area of steel exist, the zinc coating alongside the exposure area, will corrode in preference to the carbon steel and thereby provide corrosion control. This preferential protection is termed **cathodic protection** and, where damage is small, the corrosion products of zinc will tend to fill the exposed area re-establishing the barrier protection.

Finally, in addition to the barrier protection, zinc protects against under-film creep (attack under the coating) should mechanical damage be so severe as to expose the underlying steel. Under-film creep is a common failure mechanism with pure barrier protection, (no cathodic protection) where rust will spreads from any damaged or exposed areas.

Cathodic Protection

When two dissimilar metals are in electrical contact with each other, within an electrolyte, a small electrical voltage appears between them. Electrons flow to and from the dissimilar metals; one of the metals (anode) corrodes in preference to the other (cathode). This is called cathodic protection of the cathode by the anode. In other words, we use the physics of the corrosion cell (bimetallic couple), as a weapon to combat the onset of corrosion of the material that we use for our steel structures.

We say that the corroding metal is electro-negative (zinc) to the other metal (carbon steel). This behaviour is fundamental physics, so that we can confidently predict which metals will provide cathodic protection of other metals.

Fig No.2 lists a selected number of metals and is used to explain why zinc will "sacrifice" itself in order to protect carbon steel. The metals which are electro-negative to steel or will electrochemically protect (cathodic protection) iron or carbon steel are, magnesium, aluminium, cadmium and of course zinc. Of these only zinc is the most economical and practical for the use in the hot dip galvanizing process.

Other metals such as nickel, copper and brass, i.e. electro-positive to steel, are used in electro-plating. Should the barrier protection afforded by these metal coatings, be perforated (pinholes) the steel (iron) will corrode in order to protect the more noble (electro-positive) metal coating. This will be evidenced by what we refer to as corrosion creep under the protective coating.

Electrochemical Protection

Generally we refer to electrochemical protection as "sacrificial protection". This is because the zinc will sacrifice itself in order to protect the steel to which it is alloyed. It will continue to do this almost to the last atom of zinc. You can be sure that so long as some zinc or zinc iron alloy remains, even though it is in poor condition, after many maintenance free years, the underlining steel will retain its structural integrity. No other non-zinc coating can offer this benefit. Scratch type damage to the hot dip galvanized coating is often filled by oxides and carbonates formed from the zinc, tending to heal the damage and retard the rate of further corrosion.

A limited or degree of sacrificial protection is provided by zinc rich paints, but this diminishes within a short time. Sacrificial protection is not provided throughout the life of the coating, as is the case with hot dip galvanizing.

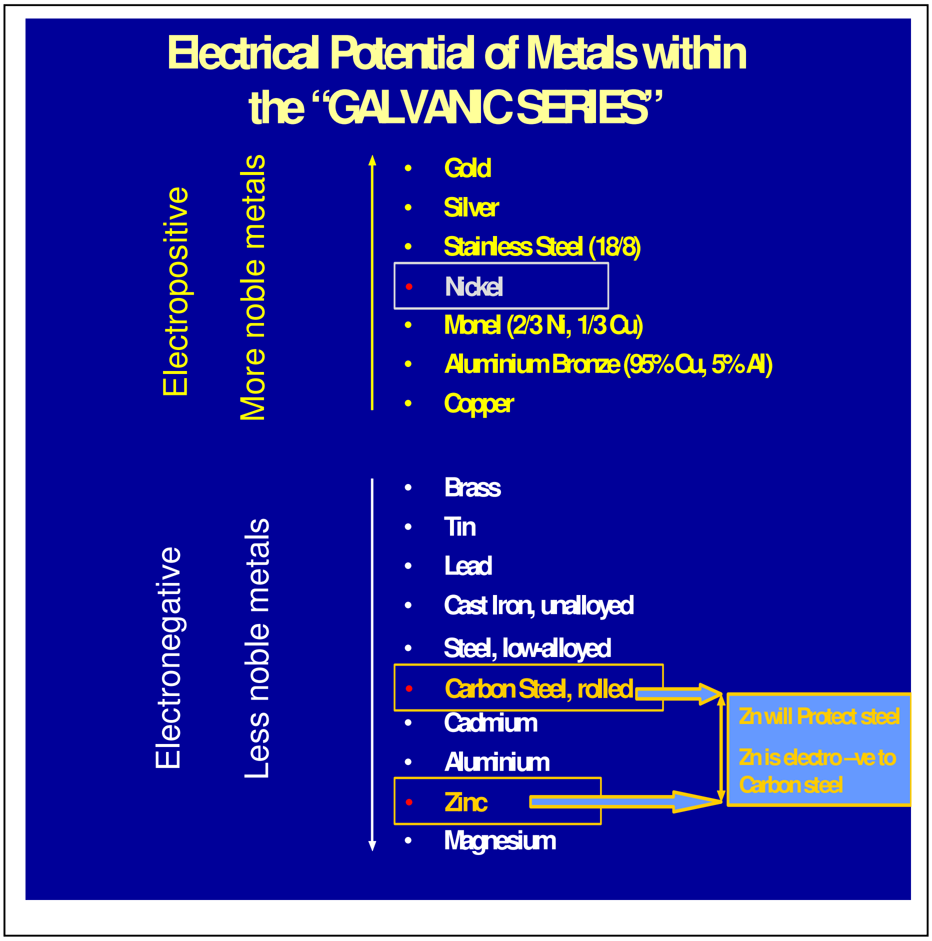

Fig 2: Galvanic Series of Metals also known as the Nobility of Metals