Coastal Engineering Technical Note

FORMS AND CAUSES OF GALVANIC CORROSION IN THE COASTAL ENVIRONMENT

PURPOSE: To outline the forms and causes of galvanic corrosion in the coastal environment.

DEFINITION: "Galvanic corrosion" is the accelerated corrosion of a metal due to electrical contact with a more passive metal.

CORROSION MECHANISM: Galvanic corrosion is a classical example of the electro-chemical cell in action. As shown in Figure 1, the anode is the corroding metal, while the cathode is a more passive metal. The current flows through the external circuit due to a difference in potential between the two metals. Galvanic corrosion can be expected to occur whenever any two different metals are electrically connected and exposed to a continuous electrolyte. The rate of attach of the anode is primarily controlled by two factors: the potential difference between and metals, and their relative surface areas.

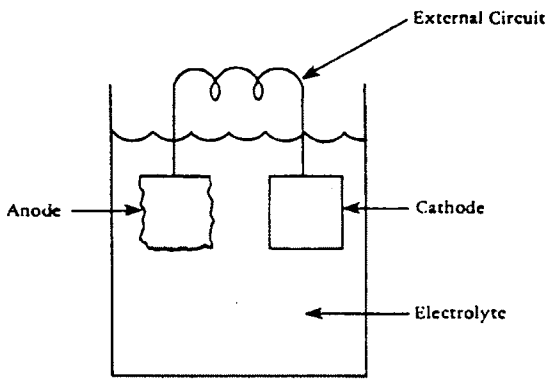


Figure 1. The galvanic cell.

POTENTIAL DIFFERENCE: The potential difference between two metals is best given by a listing of the metals in order of their activity in a common environment such as seawater. Since the actual measured potentials will vary with actual conditions, a series, called the Galvanic Series, is a relative listing and is usually given without actual potential values.

A galvanic series for seawater, most potable waters, and many soil environment is given in Table 1. The metals at the active end of the series will act as an anode when coupled to a metal below them in the series or towards the passive end. Corrosion of the more passive metal in the couple is usually reduced. The reduction is the principle behind cathodic protection.

In general, the greater the distance between position of the two metals in the series, the greater the potential difference between them and, all other things being equal, the greater the tendency for galvanic corrosion to occur. You will notice that some metals, such as the stainless steels, appear twice in the series. These are metals that depend on a passive film for corrosion resistance. In some conditions, the passive film is damaged, and the

Table 1. Galvanic Series

ACTIVE END
Magnesium
Zinc
Galvanized Steel
Aluminum Alloys
Cadmium Coated Steel
Mild Steel
Alloy Steel
Cast Iron
Monel (Active)
400 Series Stainless Steel (Active)
Solder
300 Series Stainless Steel (Active)
Lead
Tin
Muntz Metal
Manganese Bronze
Naval Brass
Yellow Brass
Admiralty Brass
Aluminum Bronze
Red Brass
Copper
Silicon Bronze
Copper-Nickel 90-10
Copper-Nickel 70-30
G-Bronze
M-Bronze
Silver Solder
Monel (Passive)
400 Series Stainless Steel (Passive)
300 Series Stainless Steel (Passive)
Silver
Inconel 625
Titanium
Graphite
Gold
Platinum
PASSIVE END

effective potential of the metal moves from a passive region to an active one. This is very important in pitting and crevice erosion.

As shown in Figure 2 the relative areas of each metal exposed are often more important than their positions on the galvanic series. This is because the total amount of current that will flow in the cell is dependent on the total area of both metals exposed. If the anode is large with respect to the cathode, the current will be distributed over a large area, and the effect at each point will be relatively slight. However, if the area of the anode is small with respect to the cathode, then the current will be concentrated in a small area, and the effect at each point could be very large. This area effect can be very important when protective coatings are used to prevent corrosion of mixed metal systems. As shown in Figure 3, if the anode is coated and there is a small defect in the coating or it becomes damaged, then the relative exposed anodic area will be small and rapid corrosion at the coating defect could occur. When coatings are used on mixed metal systems, it is best to coat both members of the couple; or if only one member is to be coated, coat the cathode and leave the anode bare.

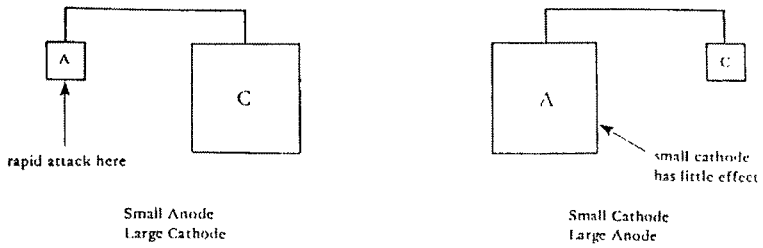
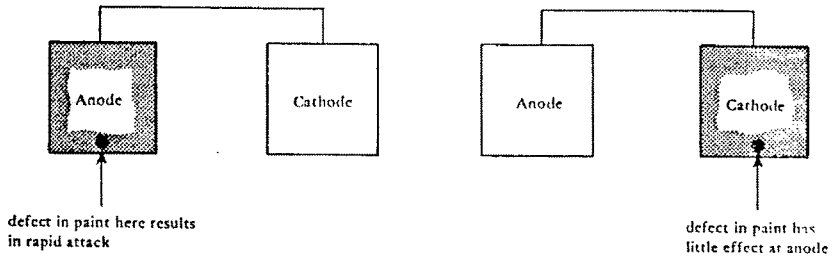


Figure 2. Effect of area ratio in galvanic corrosion.



ADDITIONAL INFORMATION: For further information contact Tom Tehada of the Naval Facilities Engineering Command at (808)-472-1254, Tom.Tehada@navy.mil.

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