Subject: Eight Forms of Corrosion

This is the second of eight primers which introduce the forms of corrosion likely to be encountered in the petrochemical, refining, fertilizer, and other industries. The eight forms have been used for decades to describe, by appearance, the common degradation mechanisms in metals and alloys.

2. Galvanic Corrosion

Galvanic corrosion can occur when combining dissimilar metals, a metal and conductive nonmetal such as a graphite filled gasket, or a single metal with different corrosion potentials in an electrolyte. If the corrosion potential difference of the couple is large enough, it results in increased corrosion of the less noble or anodic metal and reduced corrosion of the more noble or cathodic metal. Electrolytes which facilitate galvanic corrosion include soils, natural waters (fresh, brackish, seawater), acids, and bases. As the electrolyte conductivity increases, the corrosion cell becomes more efficient leading to widespread, rather than localized, attack.

The galvanic series in seawater can be used to predict which metal will be the anode and which will be the cathode when coupled together. There are also galvanic series produced using standard reference electrodes such as saturated calomel or saturated hydrogen. When using a galvanic series, it is generally advisable to avoid material combinations which have >0.2 volts of potential difference. Many galvanic series will include two positions for materials which demonstrate active-passive behavior such as 300 series stainless steels. The active-passive behavior can result in galvanic corrosion without a dissimilar metal couple and drives other forms of corrosion such as pitting and crevice corrosion. This active-passive behavior is also demonstrated by carbon steel with and without mill scale. Mill scale (magnetite or Fe_3O_4) is cathodic to bare steel and can result in galvanic corrosion when the mill scale is only removed locally such as at weld preparations. Since galvanic series do not account for polarization, and have other limitations, it is advisable to consult ASTM G82 for more information regarding the use of galvanic series when making material selection decisions.

To control galvanic corrosion, owner-operators should avoid applications which combine a large cathode and a small anode, coat the cathode (not the anode) with a nonconductive paint or liner, use isolation kits to break the metal-to-metal connection, or employ cathodic protection using sacrificial anodes or impressed current designs. Examples of the positive uses of galvanic couples include applying aluminum anodes to carbon steel off-shore structures, placing magnesium anodes in the soil beneath above ground storage tanks to protect the underside of steel floors, and the application of zinc rich coatings or galvanizing on carbon steel structural steel.

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