Subject: Eight Forms of Corrosion

This is the third 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.

3. Crevice Corrosion

As the name implies, crevice corrosion occurs in or adjacent to gaps (occluded areas) formed by gaskets, bolted or riveted connections, incompletely welded joints, and similar locations. The deeper and tighter the gap, the more likely it is to produce crevice corrosion. Teflon in particular produces very tight gaps. Since crevice corrosion requires a bulk electrolyte or a localized electrolyte to be present, non-conductive environments are not a concern. As the electrolyte increases in chlorides or decreases in pH, crevice corrosion generally becomes more problematic.

The prominent types of crevice corrosion are related to oxygen concentration cells and metal ion concentration cells. With oxygen cells, the gap is starved of oxygen and becomes anodic resulting in attack within the crevice. With metal ion cells, the gap becomes ion rich and cathodic resulting in attack adjacent to the crevice. If an environment is suspected of causing crevice corrosion, it is advisable to perform field or laboratory corrosion tests using rubber bands, Teflon castellated washers, or other devices, to form purposeful gaps.

The crevice performance of metals and alloys is determined by their chromium (Cr), molybdenum (Mo), niobium/columbium (Nb/Cb), tungsten (W), and nitrogen (N) levels. As the percentages of these elements increase in an alloy so does their resistance to crevice corrosion.

ASTM G48 provides standardized crevice test method D for nickel-based and chromium bearing alloys, and method F for iron-based alloys, i.e., various stainless steels. Both methods use an aggressive ferric chloride solution. The G48 tests are repeated at varying temperatures to determine the temperature above which crevice corrosion occurs, i.e., the Critical Crevice Temperature (CCT). NOTE: While knowing the G48 CCT is of value, it may not reflect an alloy's performance in your specific environment.

The CCT rank order produced by alloys is generally higher for materials with higher levels of those elements known to improve crevice resistance. ASTM G48 also provides two formulas for estimating the CCT of iron-based (stainless) alloys and nickel-based or chromium bearing alloys. The CCT formulas are as follows: (iron-based alloys) [CCT (°C) = 3.2(%Cr) + 7.6(%Mo) + 10.5(%N) – 81.0]; (nickel-based and chromium-bearing alloys) [CCT (°C) = 1.5(%Cr) + 1.9(%Mo) + 4.9(%Nb/Cb) + 8.6(%W) – 36.2]. As you can see, each element carries a different multiplier (positive effect), and the multiplier varies with alloy type.

During G48 testing, or through use of the G48 estimating formulas, the CCT for Type 316 stainless steel will be <0 °C (<32 °F), for super austenitic stainless AL-6XN or 254SMO it is ~38 °C (~100 °F), and for Alloy 686 and other newer generation C-Type alloys it is >85 °C (>185 °F), the maximum G48 test temperature. Higher performing alloys in CCT testing also command higher prices so their use is reserved for those applications which demand premium performance.

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