Advice & Counsel
Covering the Bases: Part 2

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[redacted] rass

[redacted] o corrode by [redacted] nly referred to [redacted]." When brass [redacted] tion, the zinc is [redacted] ce of the brass, [redacted] ch surface that [redacted] and porous. [redacted] occur when [redacted] s such as Muntz [redacted] % Zn), non- [redacted] m brass (76% Cu, 22% Zn, 2% Al) and yellow brass (67% Cu, 33% Zn), containing no dezincification inhibitor, are exposed to softened, deionized water or water containing a high level of carbon dioxide (or most any water-based corrosive medium).

about a primer on the subject?

Signed,
Cupfer L. Oye

Dear Ms. Oye
Continuing the discussion from last month:

Red brass (85% Cu, 15% Zn), Admiralty metal (70% Cu, 29% Zn, 1% Sn, 0.05% As or Sb) and arsenical aluminum brass (76% Cu, 22% Zn, 2% Al, 0.05% As), generally resist dezincification. According to Uhlig,[1] "A reduction in the zinc content of the alloy decreases its susceptibility to dezincification. For example, brasses containing more than 85% copper are practically immune. The addition of tin or arsenic (also antimony and phosphorous) to the brasses containing more than 15% zinc usually is quite effective in slowing up or inhibiting the dezincification reaction in fresh waters and in sea water. A few examples are Admiralty metal (1% tin), Naval brass (1% tin), arsenical aluminum brass (0.04% arsenic), and arsenical Muntz metal 0.4% arsenic). These are appreciably more resistant than the parent Cu-Zn alloys free of the inhibiting alloy additions."

Stress corrosion cracking
Brass alloys may fail to carry an applied load after or during

exposure to ammonia-containing environments. The most commonly encountered environment is one containing traces of ammonia, but amines and ammonium ions may produce the problem as well.

Exposure to even low levels (ppm) of ammonia has resulted in the production of fissures in cold worked brass. The micro-cracks initially formed typically grow until the brass component fails under load. This author suffered a demonstration of stress corrosion cracking after cleaning his sailboat turnbuckle (located on the forestay of the boat) with ammonia based cleaner. The turnbuckle was found in two pieces on the deck of the sailboat a few days later, as seen in the accompanying photo (Fig. 1).

In cases where the stress in the brass is a result of cold working, an annealing operation can render the brass less susceptible to failure by this mechanism. It is also believed that a heavy nickel plate will prevent the problem if all surfaces of the brass are covered. In Fig. 1, the nickel plate was missing from the surfaces of the drilled holes.

Herbert H. Uhlig

Of note, any copper-based part or other copper-based alloys are also susceptible to stress corrosion cracking if exposed to ammonia. The reaction between ammonia and copper is believed to produce water soluble cupro-ammonium ($Cu(NH_3)_4$) ions. As these ions wash off the surface, the local composition of the alloy can be changed enough to produce a micro-crack when the part is under stress.

Figure 1 - Failure of marine turnbuckle resulting from stress corrosion cracking.

In general, as the copper content of the brass increases the susceptibility to stress corrosion failure decreases. Testing cited by Uhlig has shown that higher annealing temperatures are more effective at relieving ammonia induced stress corrosion cracking versus lower temperatures. Uhlig reported results for test annealing temperatures ranging from 100 to 550°C versus reduction in tensile strength. Temperatures below about 350°C were generally ineffective.

Brass versus acids

The following information of brass versus acids was obtained from H.H. Uhlig[1]:

Nitric acid

Brass alloys are extremely rapidly attacked in nitric acid.

Hydrochloric acid

Hydrochloric acid is one of the most corrosive of the non-oxidizing acids when in contact with brass alloys. The corrosion rates in dilute stagnant hydrochloric acid solutions may range from 0.0015 to 0.025 in. per day. Water lines tests (showing the effect of oxygen) conducted at room temperature in 2N hydrochloric acid solution showed corrosion rates ranging from 0.03 to 0.06 in. per day. At elevated temperatures and high acid concentrations, the corrosion rate is still higher and may proceed with the liberation of hydrogen.

Sulfuric acid

Sulfuric acid attacks all of the brass alloys far less rapidly compared to hydrochloric acid. In the absence of oxygen, the corrosion rate of the Cu-Zn alloys in dilute sulfuric acid solutions is practically nil. For this reason, dilute sulfuric (without other ingredients such as oxidizers) is not a good candidate for pickling brass parts prior to plating.

The average rate of corrosion in stagnant solutions averages about 0.003 in. per year (ipy) in a 10% sulfuric acid solution at room temperature. The presence of an oxidizing agent such as ferric sulfate, an air interface or sodium dichromate may significantly accelerate the overall corrosion rate of brass.

Sulfurous acid

Sulfurous acid solutions are corrosive to brass. The corrosion rates may range from 0.01 ipy at room temperature to 1.0 ipy at higher temperatures; and, in addition, pitting may occur. The corrosiveness of sulfurous acid is due to the fact that this acid acts as an oxidizing agent.

Phosphoric acid

The corrosion rates at room temperature in relatively pure phosphoric acid solutions range from 0.001 to 0.20 ipy, depending on the degree of aeration. Raising the temperature will increase the corrosion rate as much as ten- to a hundredfold. The presence of oxidizing salts also increases the corrosion rate appreciably.

Fluoboric acid

This acid is only mildly corrosive to brass, but solubilizes any lead that may be present on the surface, rendering the surface active for plating.

Organic acids

Acetic acid and similar organic acids attack the Cu-Zn alloys at rates ranging from 0.001 to 0.030 ipy in quiet solutions at room temperature with limited aeration. Increased aeration and elevated temperatures may increase the rate of corrosion a hundredfold. The velocity of acetic acid relative to a brass surface increases the corrosion rate.

Citric acid as found in orange juice attacks the Cu-Zn alloys at a rate of approximately 0.002 ipy. While this corrosion rate is low, it is sometimes considered too high for foodstuffs because of the accumulation of metal ions.

Brass versus alkalis

Alkalis attack brass alloys at rates of approximately 0.002 to 0.020 ipy at room temperature under stagnant conditions. Increased aeration and elevated temperatures increase the corrosion rates from 0.020 to 0.070 ipy. Highly caustic solutions may dezincify the surface on prolonged exposure at high temperatures. ***P&SF***

Test Your Plating I.Q. #462

By Dr. James H. Lindsay

Electroless plating

1. In acid electroless Ni-P plating, what are the accepted composition ranges for low, medium and high phosphorus?
2. The most commonly used reducing agent for electroless nickel is sodium hypophosphite. Name three others.
3. The most commonly used reducing agent for electroless copper is formaldehyde. Name two others.
4. What other metals, besides nickel and copper, have been electroless plated commercially?
5. What substrate metal is not catalytic in an electroless Ni-P solution?
   a. Iron
   b. Aluminum
   c. Lead
   d. Nickel
   e. Titanium

Answers on page 17.