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Forensic Engineering Investigation of Dezincification in a Major Corrosion Litigation

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Abstract

Zinc-rich brasses with the zinc content above 30% can be involved in corrosion processes with catastrophic results. The dezincification results in a low strength copper with a porous sponge like structure.

The case, where dezincification occurred with massive impact, involved 34,000 new homes in an urban location in Nevada. These homes were constructed using building code approved plastic PEX tubing for plumbing with brass fittings. Leaks developed in the home plumbing systems after approximately 3-6 years. This failure resulted in lawsuits involving home owner associations, insurance companies, contractors, plumbers, architects, manufacturers, and suppliers.

Keywords

Dezincification, Brass, Corrosion

Background

The plumbing systems in question used Kitec brass fittings in conjunction with PEX tubing. The PEX tubing was attached to the brass fittings with compression rings or clamps. This PEX tubing is made by cross linking high density polyethylene.

The tubing used in the homes was PEX-Al-PEX with a layer of aluminum sandwiched between two layers of PEX. The purpose of this layering was to prevent diffusion of oxygen into the water system, and to prevent corrosion from occurring. Unfortunately, this arrangement also made the plastic tubing electrically conductive.

The plumbing system failures involved uniform layer type dezincification, as opposed to plug or pitting type dezincification, with subsequent loss of strength of the brass fittings. In addition to the fittings leaking, the water flow through the fittings was blocked by a white residue, referred to as "meringue", and which was composed of zinc oxide and zinc carbonate.

In the manufacture of brass plumbing fixtures, zinc in the amounts of 5 – 40% by weight is added to copper to improve its strength and machine ability. Zinc is significantly less expensive than copper, therefore, higher zinc alloys of brass are appearing more prevalently on the market. Brass concentrations

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of zinc above 30% are called duplex brass, and contain two phases. Low zinc brasses are referred to as red brass; high zinc brass is called yellow brass. The failed brass fittings were manufactured from a high zinc duplex alloy containing 35 – 40% zinc.

The amount of zinc present in the thousands of fittings involved was determined in situ, using a field portable X-ray Florescent Detector (XRF).

The copper-zinc phase diagram, Illustration 1, shows the weight percent concentrations of zinc that can produce the beta phase and create a duplex alloy.

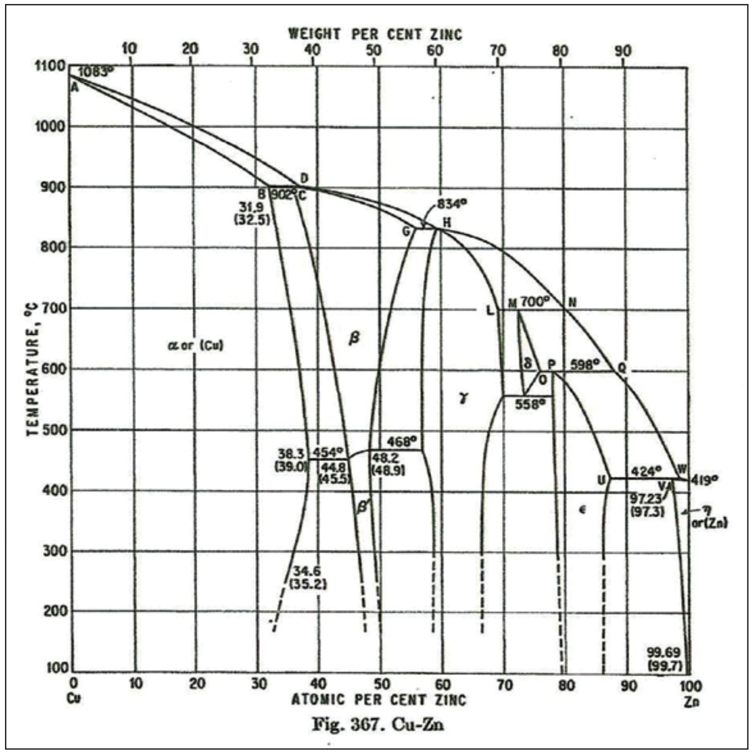

Illustration 1
Copper – Zinc Phase Diagram

Dezincification

The loss of zinc in dezincification leaves behind a porous copper sponge, as shown in the polished cross section in Illustration 2. The copper sponge is shown on the left and the unconverted high zinc brass is on the right. The dezincification process does not stop until all the zinc is gone and only the copper sponge remains.

Illustration 2
Example of Dezincification at 25X

Brass fitting and components are commonly exposed to potable water. The potable water in the area was considered non-corrosive, and had a neutral Langelier index.

Factors that decrease the extent and rate of dezincification are:

- Additions of 0.04% Arsenic, Antimony or Phosphorous.
- Addition of 1.0 % Tin (tends to embrittle)
  – (Note: Beta phase of duplex brass is not protected by these additions)
- Zinc concentrations less than 15%

Factors that increase the extent and rate of dezincification are:

- Elevated water temperature
- High Chloride content in the water
- Low Carbonate content (soft water)
- High chlorine
- Aeration
- High pH (8 – 9)
- Stagnant flow conditions
- High Zn content in the brass

Brass fittings normally are expected to last 50 years or more. However, dezincification can cause fittings to fail in just a few years. Certain brasses marked DZR are specifically designed to resist dezincification in the aggressive conditions listed above, and should be used if there is a suggestion of a problem.

Empirical Analysis

A limited empirical analysis of dezincification in various water conditions was done by Turner 2, 3 in 1961 and in 1965. It illustrates the importance of the Chloride/ Calcium Carbonate ratio in the water to control the dezincification effect. The Turner diagram, Illustration 3, defines the chloride and hardness conditions that produce dezincification. The term "temporary hardness" involves a combination of hardness, alkalinity, and pH, and is the quantified amount lost by precipitation on heating. The affect on dezincification may be due to alkalinity, rather than to hardness.

Table 1 illustrates the minimum amount of temporary hardness as CaCO3 in chloride containing water that is required to prevent the occurrence of dezincification (based on Turner).

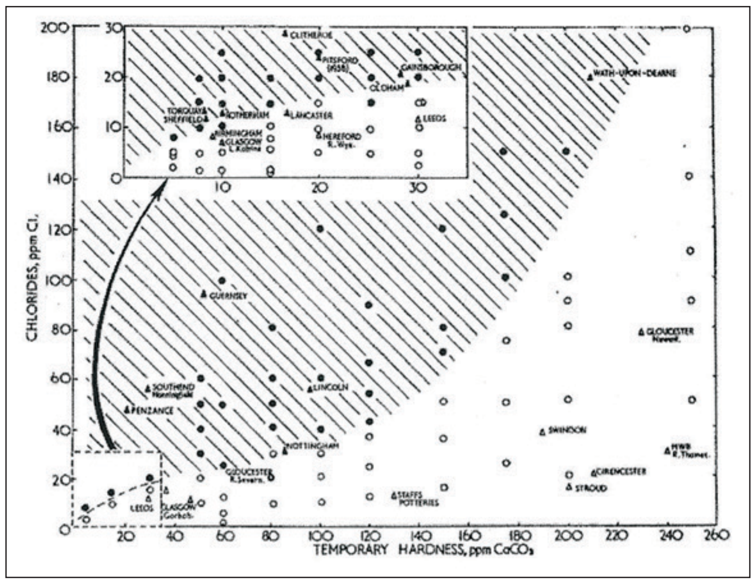

Illustration 3
Examples of Dezincification Occurrence and Locations

Chlorides (ppm)	Hardness $CaCO_3$ (ppm)
20	80
40	120
60	150
80	170
100	180

Table 1
Dezincification limits/conditions

Turner did not consider factors such as the use of water softeners or hot water re-circulation systems, the difference in water heater temperature set point, and the water velocity. However, his work still serves as a monumental contribution to help explain the water conditions that can lead to dezincification.

The Las Vegas water averaged chloride concentration of 85 and a temporary hardness of 135, thus putting it in the shaded dezincification area of the Turner chart.

Litigation Issues

The litigation issues focused on the following:

- The plumbing installation was approved by the governing agency.
- The zinc content at 35% was unusually high.
- The water was considered non-corrosive.
- Poor plumbing installation practices caused physical stress on the fittings.
- The use of an aluminum layer in the tubing was a problem.

The litigation continued with mixed results among the many parties involved.

References

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