

Zinc

Too much of a good thing results in return of an old problem: dezincification

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Zinc, the metallic element popular among consumers for its curative powers over the common cold, has been known to give valves specifiers and end users headaches. De-alloying corrosion, known as “dezincification,” was effectively eradicated from valve products some 40 years ago. Today, however, this problem has returned with the increased use of high-zinc alloys in forged and cast ball and gate valves produced outside the United States.

Specifiers who simply accept inexpensive yellow brasses without regard to whether they are standard alloys are vulnerable to dezincification problems.

Dezincification selectively removes zinc from the alloy, leaving behind a porous, copper-rich structure that has little mechanical strength. An in-service valve suffering from dezincification has a white powdery substance or mineral stains on its exterior surface. The valve may exhibit water weeping from the valve body or stem/bonnet seal.

What’s the cure? A tightly written valve specification that limits brass alloys to those containing no more than 15 percent zinc, or specification of proven dezincification-resistant yellow brass alloys, say the experts. Fur-

ther, manufacturers must be required to provide alloy designations or chemistry for the materials used in their valves and fittings.

The key to successful specification is product knowledge. Over the past decade, an evolution in alloys has occurred, and yellow brasses that are dezincification-resistant do exist. However, specifiers who simply accept inexpensive yellow brasses without regard to whether they are standard alloys—or even meet the performance requirements of standard alloys—are vulnerable to potential dezincification problems.

Foreign standards for dezincification-resistant alloys will not necessarily meet performance expectations in the United States, where specific standards defining dezincification are yet to be written.

Zinc to the rescue

In the 1940s, zinc was the cure for what ailed brass valves. The stems of the early brass valves were red brass castings. The red brass was easily machined and resistant to corrosion but the cast form was inherently inconsistent dimensionally and required a large diameter. The large-diameter stem resulted in a large valve body and excessive costs.

Manufacturers began using high-zinc wrought alloys. These alloys (mostly manganese brass) exhibited dimensional and strength improvements and allowed making diameter stems smaller. The alloys reduced cost and improved valve performance.

However, pioneering broadcast journalist Eric Sevareid once noted wryly: “The chief cause of problems is solutions.” His general observation turned out to be on-point in the case of high-zinc alloys as their use subsequently introduced another problem.

Manganese brass, containing approximately

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Zinc facts

- Occurs naturally in the earth, in the air and in foods. It is the second most common trace metal after iron naturally found in the body.
- Was discovered in 1746 by Andreas Marggraf.
- Is found in hundreds of products, including vitamins, cereals, cosmetics, pet foods, paints, fertilizers, tires, batteries, ointments, shampoos, soaps and pharmaceuticals.
- Combined with copper it makes brass.
- Is primarily used as a coating on iron and steel to protect against corrosion. Corrosion costs more than \$200 billion annually—4.2 percent of U.S. GNP.
- Makes common "cents." The U.S. penny is 98 percent zinc with a copper coating.
- Is the third most used nonferrous metal (after aluminum and copper), of which the United States consumes more than one million metric tons annually. The average person will use 730 pounds of zinc in his or her lifetime, according to the U.S. Bureau of Mines.
- Is recyclable. Over one-third of the zinc consumed in North America is recovered from old cars, bridges and buildings, among other sources.
- Is essential to human health, boosting the immune system, helping cells to grow, regulating appetite and healing wounds. Zinc lozenges can even cut short the common cold by four days. Zinc is not a carcinogen.
- Is a natural insect repellent and sun screen, protecting lips and skin.

Source: American Zinc Association

35 percent zinc, became brittle in a short time in certain corrosive water conditions. Stems suddenly broke off when operated, dropping the wedge or disc to the closed position, effectively shutting down the system. It was discovered that under certain conditions, zinc leached out of the alloy, leaving a porous copper stem.

The problem was corrected in the late 1950s and early 1960s as manufacturers began using a copper-zinc silicon alloy known as silicon brass (12 to 16 percent zinc). Since that time, dezincification of valve products had been effectively eliminated—until reintroduction of the problem, mostly among imported products.

Why dezincification occurs

Copper-zinc alloys containing more than 15 percent zinc are susceptible to dezincification. Zinc is a highly reactive metal, as seen in its galvanic series ranking. This reactivity stems from the fact that zinc has a very weak atomic bond relative to other metals. Simply, zinc atoms are easily given up to solutions with certain aggressive characteristics. During dezincification, the

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Figure 1. Typical examples of valves that have been dezincified

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more active zinc is selectively removed from the brass, leaving behind a weak deposit of the porous, more noble copper-rich metal. Two types of corrosive attack characterize dezincification: plug and uniform (or layer).

Plug-type dezincification is localized within surrounding surfaces mostly unaffected by corrosion. This type of dezincification penetrates deeply into the sidewalls of valves and fittings. Common failures associated with plug-type attack include penetration through the sidewalls that causes water seepage or loss of mechanical strength in threaded sections to the point of fracture.

Uniform-layer dezincification leaches zinc from a broad area of the surface. This type of dezincification uniformly reduces the wall thickness of the valve or fitting.

A complex set of conditions must

be present for dezincification to occur, and the occurrence is often related to region of the country. There is a high probability of dezincification occurring in Galveston, Texas, and Oklahoma City, and in regions using Colorado River water with its high salt content. A number of municipalities scattered throughout the United States also have reported valve failures from dezincification attributable to an increased chloride ion content.

Service conditions and signs

The service conditions generally present where dezincification occurs include:

- Water with high levels of oxygen and carbon dioxide (uniform attack).
- Stagnant or slow moving waters (uniform attack).
- Slightly acidic water, low in salt

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content and at room temperature (uniform attack).

- Soft, low pH and low mineral water combined with oxygen, which forms zinc oxide (uniform attack).
- Waters with high chloride ion content (uniform attack).
- Neutral or alkaline waters, high in salt content and at or above room temperature (plug-type attack).

Common signs that dezincification is occurring include:

- Presence of a loosely adhering white deposit of zinc oxide on the exterior of the valve.
- Presence of mineral stains on the outer surface of the valve.
- Water weeping from the valve body or stem/bonnet seal.

End users of forged yellow brass gate, globe or ball valves with high-

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zinc content should watch carefully for any sign of dezincification of valves in service (see Figure 1). Resultant valve failure could damage or destroy property in the immediate area around the valve.

Confidence level

Brass alloys containing no more than 15 percent zinc are highly resistant to dezincification. Valve bodies fabricated of ASTM B-61 (4.5 percent zinc), B-62 (5.0 percent zinc) or B-584 (8

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percent to 12 percent zinc) brass proved to be resistant to dezincification over decades of use. Silicon brass, ASTM B-371 Alloy 694 (14.5 percent zinc) or B-99 Alloy 651 (1.5 percent zinc) also proved resistant.

Yellow brasses with more than 15 percent zinc must also have inhibitors to minimize dezincification damage. These brasses use arsenic, antimony or tin as inhibiting agents. Such alloys may require modifications to the manufacturing process that increase the cost.

There have been rare instances of low-zinc brass failing because of dezincification. Still, specifiers will find that selecting brass valves containing less than 15 percent zinc offers the highest level of confidence that end users will remain free of headaches caused by dezincification. ☺

Photo courtesy of Nilbco Inc.

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Glossary of terms

Dezincification: A form of de-alloying corrosion in which the zinc-rich constituent of a brass alloy is selectively removed.

Galvanic series: Galvanic corrosion potential is a measure of how dissimilar metals will corrode when placed against each other in an assembly. Metals close to one another in the series generally do not have a strong effect on one another, but the farther apart two metals are, the stronger the corroding effect on the one higher in the list.

Noble (cathodic): Describes metals on the galvanic chart that are more electrochemically positive and less reactive.

Active (anodic): Describes metals on the galvanic chart that are more electrochemically negative and more reactive.

Zinc oxide: A compound of zinc and oxygen often observed as a white powder on the exterior surfaces of components attacked by dezincification corrosion.

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