# Tech Talk

## Which Sealless Pump...

*continued from page 3*

create heat due to the transmission losses in the containment\isolation can. In both designs the pumped liquid will absorb this heat. For liquids near their vapor pressure, liquids with low specific heats or liquids which chemically react (e.g. polymeryl) with increased temperatures it may be necessary to provide external cooling to prevent these conditions from occurring.

**Note:** Non-metallic and lined magnetic drive pumps are today being used more frequently as these design offer superb corrosion resistance while eliminating the eddy current losses and heating effect inherent with magnetic drive pumps which use metallic containment shells.

**Maintenance Practices**

Although the goal is that the sealless pump you buy will solve many of your problems and provide many years of trouble-free operation you would be naïve to think you'll never have to work on that pump again. One of the essential elements of a sound maintenance program begins with alignment of the pump and motor. If proper alignment cannot be guaranteed then one should consider either the canned motor design or a close-coupled design of a magnetic drive pump as alignment is guaranteed by machined components in the pump designs.

Another consideration to be made is the labor policies at your site. If separate disciplines for mechanical and electrical service will be required then a magnetic drive pump may offer some advantages as the pump and motor are separate pieces of machinery which will allow the pump to be maintained without having to disturb the electric motor. (Note: Prior to performing any maintenance on any machine it is recommended that the driver power be locked out to prevent against an injuries) Lastly, as with any good plan one must have a contingency plan. When developing your contingency plan you must decide what you will do if the pump needs to be replaced or if the pump cannot be repaired quickly. The worst case situation for both designs usually begins with dry running or cavitation such that the pump is operated dry and suffers a failure resulting in a breach of containment. In the case of the magnetic drive pump this may require both the drive and driven magnets to be replaced as well as the containment shell and bearings. Similar repairs would be required to a canned motor pump, however a breach of containment may require that the stator be re-wound, which likely means that the pump will need to be returned to an off-site repair shop. Because of this, a magnetic drive pump may offer an advantage as they can be repaired on site and typically magnetic drive pumps comply with the same dimensional standards as mechanically sealed pumps which would allow a sealed pump to be installed to keep the process running.

**Installation**

The last item that one will need to consider is the proposed installation site. If the site is space constrained, or if flexible foundations for pumps are employed, then a canned motor pump may offer some advantages due to its compact unitized arrangement. Alternately, the closed-coupled magnetic drive pump is equally compact and rigid.

So in conclusion the sealless pump designs available in the market today can provide users with solutions to solve many of their process design challenges. However one should be aware that sealless pump are not the 'fits-all, fix all" solution to all process problems. A pump experiencing problems because of improper operation (cavitating, dry running, etc) or poor maintenance practices (e.g., misalignment, improper lubrications, etc) will not be cured solely by the installation of either a magnetic drive or canned motor pump. It is important to evaluate all aspects of the pump installation; operation conditions and maintenance to best select the pumping solution for a given application.

*I would like to recognize Craig Bailey, Strategic Account Manager, ITT Industries – Goulds Pumps Houston, TX for his contributions to this article.*

# Material Matters

## The Suitability of Cast Copper Alloys In Chlorinated Water Services

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### Question:

***Which is better for chlorinated water services; Silicon-Brass or Silicon-Bronze? Also, why is it that older pumps made from Leaded-Red-Brass (Alloy UNS C83600) appear to resist corrosion better than the alternative "lead free" materials?***

**Introduction**

Copper and copper alloys comprise one of the largest families of corrosion resistant engineering materials commonly utilized for fresh and potable water services. These alloys are widely used in fresh waters, and are selected primarily for corrosion resistance, good mechanical properties and economy. They are often specified for pumping applications on services, which may, or may not be chlorinated.

Since conventional copper alloys exhibit poor machinability, small amounts of lead have historically been added to improve machinability and casting pressure tightness. The element's primary function is to improve pressure tightness by sealing the interdendritic spaces (i.e. shrinkage porosity) that forms as these wide freezing range alloys solidify. Lead also reduces galling tendencies, and has been added to improve frictional and wear properties in certain alloys.

However, lead is mostly insoluble in solid copper and is finely distributed throughout the alloy matrix. Since lead is considered toxic, the leaching of lead into potable water can result in undesirable health issues. Concerns regarding lead pickup in aggressive drinking waters have restricted the use of leaded alloys in pumps. Because of toxicity concerns, "lead free" alloys have generally replaced the leaded alloys for potable water systems. The most active area of copper alloy development currently is in the plumbing goods, valve, and pump industries, where a mandate to reduce trace levels of lead from drinking water has prompted a search for suitable replacement alloys. Among the many

# Material Matters

"lead-free" compositions being used are the silicon-brasses and bronzes, aluminum-bronzes, and newer alloys containing bismuth.

This article is primarily intended to familiarize the reader with some of the concerns and differences regarding silicon-brass and silicon-bronze alloys, and provide guidance for proper selection. The discussion presented shall focus on these alloys, and their suitability in chlorinated water services.

**Differences Between Brass and Bronze**

Brasses are the most widely selected and commonly cast copper alloys. They are copper alloys in which zinc is the principal alloying element. Bronzes however, are copper alloys in which the major alloying addition is neither zinc nor nickel. By definition, the distinction between brass and bronze is a matter of zinc content, with brass having more than 5% zinc by weight, and bronze generally having less. Low zinc alloys retain the face-centered-cubic (fcc) alpha (a) structure, while the high zinc brasses (39% Zinc) contain predominantly the harder body-centered cubic (bcc) beta (b) structure. Alloys containing intermediate levels of zinc usually exhibit a duplex a+ b structure, which makes them easier to cast, form and machine, but sacrifices some of its corrosion resistance.

The red-brasses are alloys of copper, zinc, tin, and in many cases lead, such as in the widely used leaded-red and semi-red-brasses. The leaded-brasses can contain up to 8% lead, which greatly improves machinability and corrosion resistance *(lead acts as an inhibitor)*. The leaded-red-brass (Alloy UNS C83600) used to account for more tonnage than any other cast copper alloy poured. However, as the trend away from lead containing materials continues, alternative materials are being utilized as a substitute. A "reddish" copper color is typical of these alloys (hence the name) which contain less than 8% zinc, and these relatively high copper alloys retain the face-centered cubic alpha (a) structure of pure copper.

Casting alloys of copper containing silicon are widely favored for their good foundry characteristics and corrosion resistance. The copper-silicon alloys are generally divided into two classes; namely the silicon-brasses or silicon-bronzes. Silicon-brasses are defined as those copper-based alloys containing silicon and over 5 weight % zinc such as Alloy UNS C87500. Silicon-bronzes are defined as copper-based alloys containing silicon and generally less than 5 weight % zinc. In practice, two silicon-bronze compositions are commonly available, one being essentially zinc-free (Alloy UNS C87300), while the others are low zinc (Alloy C87600 and C87610) respectively. The zinc free alloys offer somewhat superior corrosion resistance in more aggressive environments.

Alloys containing less than 4 weight % silicon generally solidify as single-phase "alpha" solid solutions. As significant amounts of zinc are added to these alloys the single-phase "alpha" solid solution is replaced by a dual-phase "alpha-beta" structure. This duplex "alpha-beta" structure is typical of the silicon-brasses. While, strength is somewhat enhanced by the presence of the harder beta phase, corrosion resistance is reduced making these alloys susceptible to dealloying in certain environments.

**Copper Alloy Corrosion**

Corrosion in waters occurs when some condition either prevents formation of the protective oxide or carbonate surface films, or breaks them down due to the redox conditions of the system. Dissolved gases such as oxygen and/or carbon dioxide, as well as aqueous chlorine and sulfide species play complicated roles in copper solubility, and in determining the stability of the protective surface films. In potable or municipal waters, the oxidizing agents (electron acceptors) that increase corrosion of copper are predominantly dissolved oxygen and aqueous chlorine (HOCL0, OCL-, and Cl2) species. In the absence of dissolved gases or oxidants, water does not easily corrode copper.

Waters that tend to deposit calcium carbonate are termed "non-aggressive," while waters that do not are termed "aggressive." The corrosion literature on copper alloy chemistry in municipal and natural water systems suggests that the basic cupric-hydroxy-carbonate compound [$Cu_2(OH)_2CO_3$] (malachite) should form a passive layer on copper alloys, which greatly reduces the corrosion potentials. Corrosion of copper by dissolved $CO_2$ or "carbonic acid" as well as aqueous chlorine species has been widely reported, although the mechanisms of attack have been a matter of some debate. Much confusion still appears to exist within the water treatment field regarding what constitutes corrosive waters.

Although copper alloys are widely used for pumps and valves, and other plumbing goods, they are often attacked by many natural waters; especially soft waters with high oxygen and carbon dioxide contents. In these waters, carbonic acid is formed, which lowers the pH and

*continued on page 6*

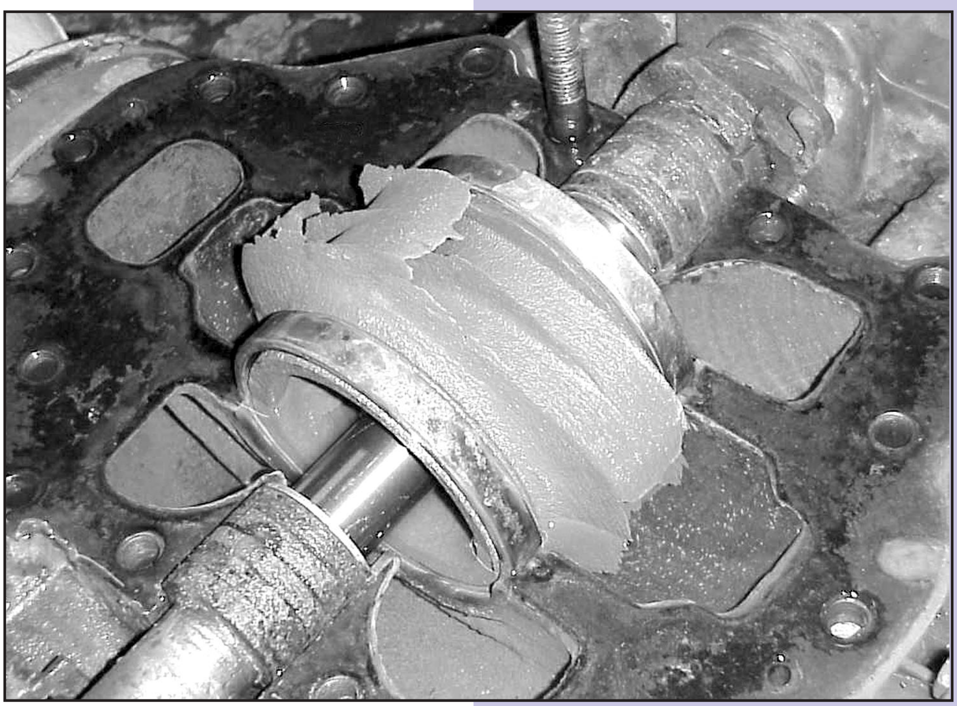

*Figure 1*

# Material Matters

## Cast Copper Alloys...

*continued from page 5*

affects the development of the protective surface layers. The complicating nature of the presence or absence of important oxidants and disinfectants such as dissolved oxygen, free chlorine, and other aggressive species makes the alloy stability uncertain.

Electrochemical studies have shown that the presence of chlorine can cause modification to protective films, which can lead to rapid attack due to large potential differences between the altered surface films and bare metal. Chlorine has also been shown to causes a large potential shift in the positive direction, which further increases the corrosion potential. Protective films can be modified into soluble compounds containing significant levels of chlorine such as copper (cupric) chloride ($CuCl_2$) or copper (cupric) hydroxy chloride [($Cu_2(OH)_3Cl$)]. Green colored corrosion deposits are often indicative of these chloride reactions.

**Environment Limitations**

While copper alloys resist a wide variety of waters, saline solutions, alkaline solutions, and organic chemicals; copper is susceptible to attack in waters containing mineral or oxidizing acids, oxidizing metallic salts, sulfur (sulfide) or nitrogen (ammonia or amines) compounds, as well as moist chlorine.

The presence of chlorine in waters has little measurable effect on leaded red brass (Alloy UNS C83600) and many other high lead copper alloys due to their metallurgical properties and superior corrosion resistance (i.e. lead resists corrosion and inhibits dealloying). As previously discussed chlorine can react with the higher zinc containing silicon-brass alloys in such a way that it increases the rate of selective attack resulting in "dezincification." Damage typically exhibits an appearance similar to that shown in Figure 1.

Limitations on the use of certain copper alloys include conditions such as polluted waters as well as chlorinated waters. Sulfides are common in polluted waters, and beneath long standing sediments where anaerobic conditions may exist, sulfate-reducing bacteria are often found. Free chlorine is typically encountered as a biocide in treated waters.

In aqueous environments, the corrosion product predominantly responsible for protection is copper (cuprous) oxide ($Cu_2O$), cupric hydroxide [$Cu(OH)_2$], or cupric-hydroxy-carbonate [$Cu_2(OH)_2CO_3$] as stated earlier. Reaction of copper with sulfur (sulfides) to form copper sulfide (CuS or $Cu_2S$) or sulfate salts; or chlorides to form basic chloride salts or cupric-hydroxy-chloride as previously discussed, precludes the use of certain copper alloys in environments known to contain these damaging species.

The corrosion resistance of uninhibited silicon-brass (Alloy UNS C87500) is good in unpolluted and non-chlorinated fresh waters. However, they are particularly susceptible to dezincification when used in stagnant or slightly acidic waters, slow moving brackish waters, or chlorinated waters. On the other hand, inhibited alloys (those containing lead, tin, antimony, or bismuth), or low zinc silicon-bronzes (Alloy UNS C87300 or C87600) are highly resistant to dezincification, and are often used successfully in these type waters. For more aggressive waters, the silicon-bronzes, and other alloys such as aluminum or nickel-aluminum-bronzes offer superior corrosion resistance.

**Dezincification**

Certain copper alloys are more susceptible to various types of localized corrosion, which greatly affects their usefulness. For example, the silicon-brass alloys can suffer from localized selective leaching or "Dezincification" in certain environments. Selective leaching (also referred to as de-alloying corrosion) is a corrosion process in which one constituent of an alloy is preferentially removed, leaving behind an altered residual structure or none at all. Dezincification of silicon-brass is common in aggressive waters by a mechanism where the zinc in the alloy is selectively removed or dissolved from the copper matrix. The extent of this attack is greatest in uninhibited brasses that contain 15% or more zinc by weight

Two theories to clarify the mechanism of dezincification are prevalent. In the first, the copper and zinc in the alloy are believed to both dissolve. As the zinc is removed (usually as a soluble salt), the copper component in solution re-deposits or plates back onto the alloy surfaces. These copper enriched surfaces are revealed by a characteristic "reddish" appearance. See Figure 1. In the second theory, the zinc rich beta-phase in the dual structure alloy is selectively dissolved due to electrochemical and galvanic activity, leaving behind a porous residue of the noble copper matrix or alpha-phase. As the zinc is removed the component losses much of its strength and rapid erosion-corrosion occurs. Many believe that both of these mechanisms take place to some degree.

**Recommendations**

Dezincification of brasses with a dual-phase structures are generally more severe, particularly if the second phase is continuous. Alloys with copper contents of 85% or more by weight resist dezincification, and corrosion resistance in aggressive waters favors higher copper content and low-zinc content. Brasses with copper contents of 85% or more, or inhibited brasses (those containing lead, tin, antimony, or bismuth) resist dezincification, as well as the silicon-bronzes.

The corrosion resistance of silicon-brass (e.g. alloy C87500) is adequate for most fresh water environments. However, these alloys are subject to dezincification in stagnant, acidic or chlorinated waters. It is for this reason that silicon-bronze (alloys C87300 and C87600) is preferred, and recommended for chlorinated and other aggressive waters, rather than silicon-brass.