DISSIMILAR METALS IN DOMESTIC HOT WATER SYSTEMS

It has long been known that the improper application of dissimilar metals, not properly pre-selected for compatibility, can lead to premature equipment failure due to galvanic action. Much work has been done on this subject over the years to determine what is, and what is not, compatible. The actual origin of the word "galvanic" goes back to the 1700's when Luigi Galvani first observed the generation of voltage from dissimilar metals which others later learned leads to galvanic corrosion. By the 1800's, work by others demonstrated the harmful effects of galvanic corrosion and also developed criteria for selecting dissimilar materials that are fully compatible.

A simplistic approach to this subject would be to never utilize dissimilar metals in a system. This, however, would overly restrict design options. Consider, for example, the wide use of soldered copper piping systems. Soldering is a widely utilized method of joining copper tubing and fittings to form a water plumbing system. Mixtures of two or more metals are utilized to make solder. In the past the most widely utilized solder was tin/lead in ratios typically varying from 40/60 to 50/50. These are known as soft solders and are still one of the easiest to use solders ever developed.

More recently it has been determined that lead in our food or drinking water is not good for our health, especially our mental health. For that reason the earlier tin/lead solders have been replaced with tin/antimony. While tin/antimony is a little harder to work, it is being utilized to avoid introducing sources of lead into potable water. The point is, since their inception, copper plumbing systems have been successfully utilizing dissimilar metals (i.e., copper and solder). No more proof than that is needed to demonstrate that properly selected dissimilar materials can and are being successfully used every day in plumbing systems. Copper water piping was introduced to the United States in the late 1920's and by 1970 it had become the material of choice in home construction.

After realizing this is an ongoing methodology that can, is, and will continue to be employed successfully, we will now address the principles that should be followed to ensure metal compatibility. To identify the compatibility of metals, an "Anodic Index" of various metals relative to gold as a reference has been determined in laboratory studies.

See Table and Guidelines below:

Anodic Index

Metallurgy	**Index (V)**
Gold, solid and plated, Gold-platinum alloy	0.00
Rhodium plated on silver-plated copper	0.05
Silver, solid or plated; monel metal. High nickel-copper alloys	0.15
Nickel, solid or plated, titanium alloys, Monel	0.30
Copper, solid or plated; low brasses or bronzes; silver solder; German silvery high copper-nickel alloys; nickel-chromium alloys	**0.35**
Brass and bronzes	**0.40**
High brasses and bronzes	**0.45**
18% chromium type corrosion-resistant steels	**0.50**
Chromium plated; tin plated; 12% chromium type corrosion-resistant steels	0.60
Tin-plate; tin-lead solder	0.65
Lead, solid or plated; high lead alloys	0.70
Aluminum, wrought alloys of the 2000 Series	0.75
Iron, wrought, gray or malleable, plain carbon and low alloy steels	0.85
Aluminum, wrought alloys other than 2000 Series aluminum, cast alloys of the silicon type	0.90
Aluminum, cast alloys other than silicon type, cadmium, plated and chromate	0.95
Hot-dip-zinc plate; galvanized steel	1.20
Zinc, wrought; zinc-base die-casting alloys; zinc plated	1.25
Magnesium & magnesium-base alloys, cast or wrought	1.75
Beryllium	1.85

- For ***harsh environments***, such as outdoors, high humidity, and salt environments fall into this category. Typically there should be no more than 0.15 V difference in the "Anodic Index". For example; gold - silver would have a difference of 0.15V being acceptable.
- For ***normal environments***, such as storage in warehouses or non-temperature and humidity controlled environments. Typically there should not be more than 0.25 V difference in the "Anodic Index".
- For ***controlled environments***, that are temperature and humidity controlled, 0.50 V can be tolerated. Caution should be maintained when deciding for this application as humidity and temperature do vary from region to region.

It has been established that the potential for galvanic corrosion can be controlled by selecting metals with Anodic Indexes that are close to each other as documented and quoted above. Even in harsh environments, a difference of 0.15 volts or less in the Anodic Index's of two metals is fully acceptable. As an example gold and silver have an Anodic Index difference of 0.15 volts and both can and are often successfully utilized together. The Anodic Index difference of soft solder and copper is actually 0.30, so the 0.15 guideline is obviously conservative since 0.15 has been determined to be satisfactory, even in harsh environments.

By considering what has been demonstrated for many years to be acceptable and by applying the guidelines that have been developed by the scientific community we can conclude that having high chromium stainless steel and copper in the same plumbing system is completely acceptable. See table items highlighted in bold. This conclusion is fully supported by "euro/inox" "The European Stainless Steel Development Association" and by "Engineering Edge" at www.engineeringedge.com.

References:

Euro/inox is the European market development association for stainless steel. In their Web-site online question and answer section they ask the question "Can stainless steel be used in combination with copper or galvanized steel for repair of domestic plumbing systems"? They answer "No problems are to be expected when stainless steel is combined with copper plumbing, as both materials have similar corrosion potential in potable water. Plumbing components made of hot-dip galvanized steel can also be combined with stainless steel. However, couplers of copper zinc alloys or red brass are recommended".

www.corrosion-doctors.org and www.engineeringedge.com both publish the Anodic Index chart and the guidelines printed in this paper.

Larry Ashton - PE