MATERION
Aleaciones de Berilio S.L.
Buen Suceso 13 - 28008 Madrid - tel. 915 488 187 - fax 915 489 307 - paco_aguirre@aleacionesdeberilio.com

TECH BRIEFS

Chloride Stress Corrosion Cracking of High Performance Copper Alloys

Stress Corrosion Cracking (SCC) is an environmentally assisted failure caused by exposure to a corrodant while under a sustained tensile stress. SCC is most often rapid, unpredictable and catastrophic. Failure can occur in as little as a few hours or take years to happen and is commonly observed in the absence of other forms of corrosion, such as general or crevice corrosion.

Most alloys are susceptible to SCC in one or more environments requiring careful consideration of alloy type in component design. In oxygenated aqueous chloride environments austenitic stainless steels and many nickel based alloys are known to perform poorly. These alloys demonstrate a rapid decrease in failure time with increasing applied stress. Use of these alloys often requires additional processing, such as shot peening, cathodic protection or the application of protective coatings to prolong the structure life. However, the additional processing requirements add significantly to the cost of use.

Numerous service conditions exist where high chloride conditions are present. Aqueous chloride environments are common in the Oil and Gas industry in both the downhole and production situations. Highly concentrated hot brine or potassium chloride are common in exploration drilling requiring the use of chloride SCC resistant materials such as high copper alloys. Seawater conditions are another area where copper beryllium alloys, for example, have been exceptionally successful for undersea electronic and fiber optic housings.

A method of commonly evaluating material susceptibility to Chloride SCC is ASTM Standard Practice G36, “Performing Stress-Corrosion Cracking Tests in a Boiling Magnesium Chloride Solution”. This accelerated test method incorporates C-ring specimens of various alloys of steel, nickel and copper to determine the failure time as a function of applied stress. The specimens evaluated were loaded to an applied stress of 100% of the yield strength and immersed into the solution as described by the standard practice. If the specimens failed in less than 1000 hr, additional specimens were loaded to 50% of the yield strength and tested in solution. Copper beryllium alloy C17200 was tested at three levels of strength to determine the effect of aging on resistance to chloride SCC.

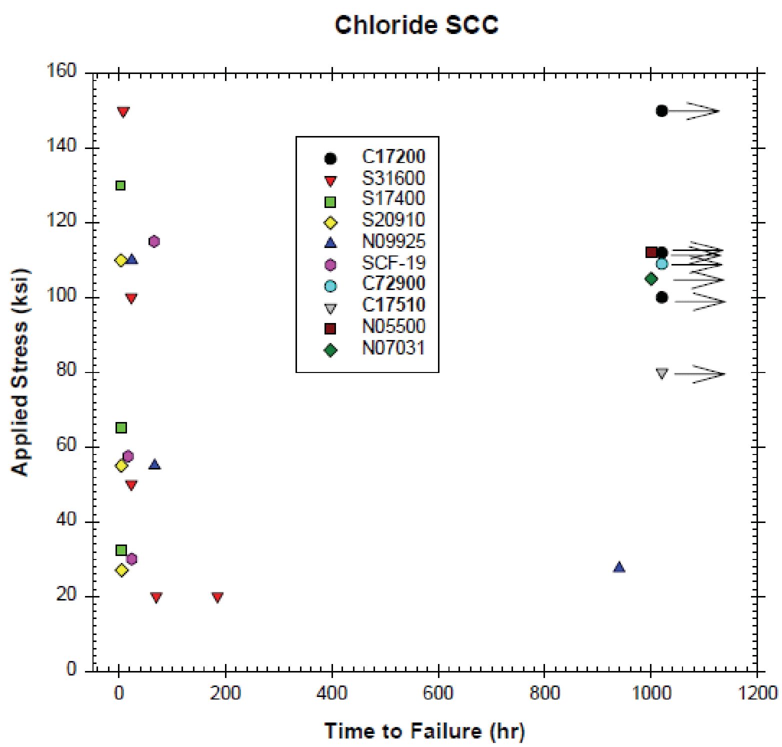
The results shown in the graph indicate that the stainless steel alloys are highly susceptible to chloride SCC, as are some of the nickel-based alloys. These alloys fail by cracking in times as short as several hours, even at a fraction of their yield strength. The data also show that several high performance copper-based alloys demonstrate SCC resistance at strength levels equal to, or greater, than several SCC resistant nickel alloys. Copper beryllium C17200, for example, provides the greatest strength and SCC resistance of the alloys evaluated. The excellent corrosion resistance is independent of strength, shown at 0.2% yield strengths ranging from 100 ksi to 150 ksi (689 MPa to 1034 MPa). A lower strength, but higher conductivity copper beryllium alloy, C17500, is also shown to be resistant to chloride SCC. A new commercially available spinodally hardened Cu-Ni-Sn alloy, Brush ToughMet® 3 AT, offers SCC resistance at a yield strength of 110 ksi (758 MPa).

When design considerations require a chloride SCC resistant alloy, other material properties and attributes should also be considered. For example, AT0024/0800 instrumentation for directional sensing during downhole oil and gas exploration may require high strength and non-magnetic behavior. Other downhole drilling situations require bending of a drill string over a tight radius defining the need for a low modulus alloy which reduces generated stress levels. Wear and friction behavior may be necessary for bushings and wear surfaces exposed to SCC inducing environments. These design requirements eliminate the high nickel alloys from the application because of their ferromagnetic behavior, high elastic modulus and propensity for galling and seizing. High strength copper alloys, such as the copper beryllium and spinodal alloys, are the engineering solution in many applications where the material demands are high.

SAFE HANDLING OF COPPER BERYLLIUM

Handling copper beryllium in solid form poses no special health risk. Like many industrial materials, beryllium-containing materials may pose a health risk if recommended safe handling practices are not followed. Inhalation of airborne beryllium may cause a serious lung disorder in susceptible individuals. The Occupational Safety and Health Administration (OSHA) has set mandatory limits on occupational respiratory exposures. Read and follow the guidance in the Material Safety Data Sheet (MSDS) before working with this material. For additional information on safe handling practices or technical data on copper beryllium, contact Materion Brush Performance Alloys, Technical Service Department at 1-800-375-4205.

ToughMet® is a registered trademark of Materion Brush Inc. Incoloy® and Monel® are registered trademarks of Special Metals Corporation. Nitronic® is a registered trademark or Armco Inc. SCF 19® and Pyromet® are registered trademarks of Carpenter Technology Corporation.



C17200 - Materion Brush Performance Alloys 25 AT; Tube, PA 150 ksi YS; Forged UA, 110 and 100 ksi YS
S31600 - AISI 316 SS A, Tube, 40 ksi
S17400 - 17-4 PH, Bar, 127 ksi YS
S20910 - Nitronic® 50, 103 ksi YS
N09925 - Incoloy® 925, 106 ksi YS
SCF 19 - SCF-19® (Carpenter Technology), 120 ksi YS
C72900 - Materion Brush Performance Alloys ToughMet® 3 AT110, 110 ksi YS
C17510 - Materion Brush Performance Alloys 3 AT Tube, 80 ksi YS
N05500 - Monel® K500 (Huntington Alloys, Inc.), 112 ksi YS
N07031 - Pyromet® 31 (Carpenter Technology), 106 ksi YS