



Chloride Stress Corrosion Cracking Resistance of High Performance Copper Alloys

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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.

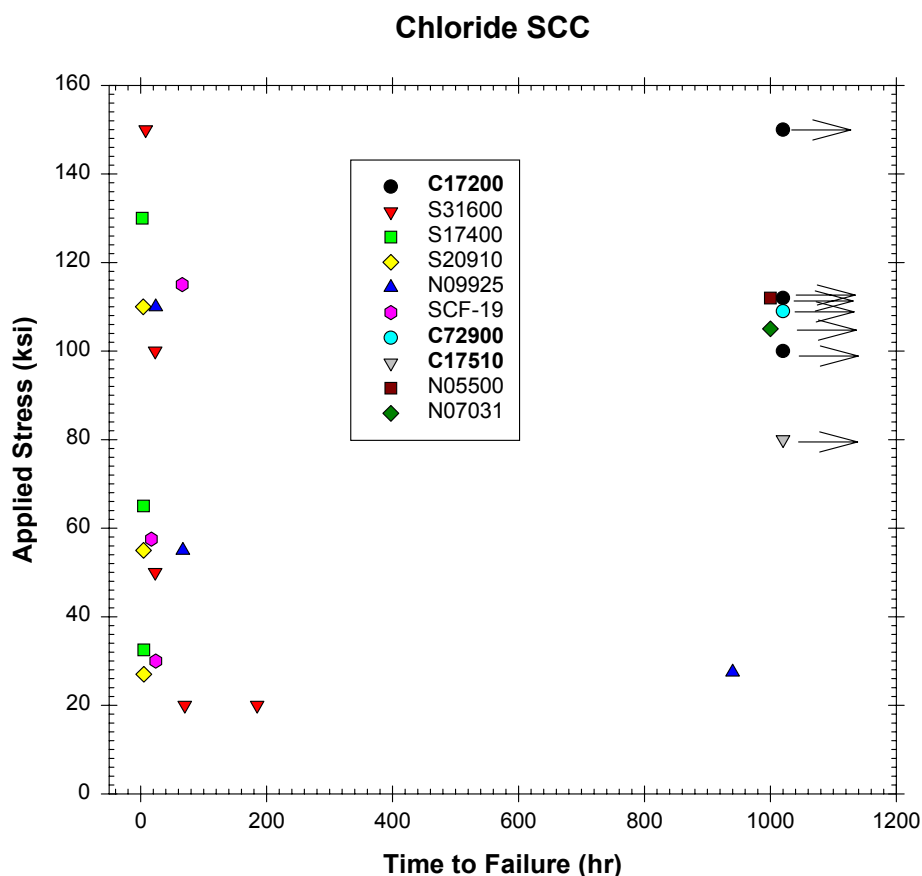
The results shown in the graph indicate that the stainless steel alloys are highly susceptible to chloride SCC, as are some of the nickel-based alloys. These alloys fail by cracking in times as short as several hours, even at a fraction of their yield strength. The data also show that several high performance 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. 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.

When design considerations require a chloride SCC resistant alloy, other material properties and attributes should also be considered. For example,

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 needs 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.

If you require additional information, or technical assistance, please contact Brush Wellman's Technical Service Department at (800) 373-4205.



C17200 - Brush Wellman Alloy 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 - Brush Wellman Toughmet 3 AT, 110 ksi YS
C17510 - Brush Wellman Alloy 3 AT Tube, 80 ksi YS
 N05500 - Monel K500 (Huntington Alloys, Inc.), 112 ksi YS
 N07031 - Pyromet 31 (Carpenter Technology), 106 ksi YS