MATERION

Tech Brief

High-performance Alloys

Material Considerations for Stress Corrosion Cracking and Sulfide Stress Cracking

Copper-beryllium Alloy 25 provides suitable resistance to stress corrosion cracking (SCC) and sulfide stress cracking (SSC). The high-strength nature of this copper beryllium alloy, as well as the conveyed resistance to SCC and SSC, make this material the alloy of choice when considered for an aqueous chloride environment.

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CONTEXT

Stress corrosion cracking is cracking induced by a corrosive environment while under sustained stress, usually tensile. SCC is often rapid, unpredictable and catastrophic. Failure can occur in as little as several hours or can take many years, and is commonly observed in the absence of other forms of corrosion, such as general or crevice corrosion. Crack propagation during SCC is the result of pitting corrosion on the material surface. The pitting acts to initiate cracking by imposing increased stress.

Sulfide stress cracking is a type of hydrogen cracking induced by sustained stress in the presence of water and hydrogen sulfide. Like SCC, failure can occur with no indication. Unlike SCC, the cracks are not necessarily the result of surface pitting and may initiate within the material itself. The detection of the fine cracks caused by SSC requires specialized observation and inspection methods.

Instances of SCC and SSC are challenges often seen in the heavy machinery used in harsh environments, such as in the oil and gas industry, due to the sour or aqueous chloride conditions present. Many alloys are susceptible to these cracking types, requiring deliberate material selection. Performing additional processing such as stress-relieving heat treatments, shot peening, and external applications (like cathodic protection or protective coatings) can prolong material life and reduce SCC and SSC. These additional processes may decrease the likelihood of failure but pose a separate challenge in terms of project cost.

TESTING INFORMATION AND SCOPE

A common method of evaluating material susceptibility to SSC and SCC is NACE TM0177, "Laboratory Testing of Metals for Resistance to Sulfide Stress Cracking and Stress Corrosion Cracking in H_2S Environments". The testing method employed the recommended four-point bend (4PB) configuration at 100% minimum design yield strength (MDYS) according to appropriate aerospace standards Metallic Materials Properties Development and Standardization (MMPDS).

Testing of Alloy 25 was conducted to establish its performance and corrosion susceptibility in sour and magnesium chloride environments. The following tempers were tested: Alloy 25 DSTO, Alloy 25 DSTU, Alloy 25 AT and Alloy 25 HT. The tempers were tested at four severity levels of conditions following NACE standards; as to varying severity, each level posed an increase in chloride concentration and temperature, as well as other changes to pH and ppH_2S.

TESTING RESULTS

The results of testing indicated that Alloy 25 is minimally prone to cracking in the environments tested. Of the samples tested, there was only one specimen with confirmed cracking: Alloy 25 AT with NACE Level V exposure at 100% MDYS.

Localized attacks and inter-granular corrosion were observed in the samples throughout testing, as expected. However, in terms of exhibiting SSC and SCC behavior, no cracking or prominent thinning was observed in any Alloy 25 samples for NACE levels I and II. Only at NACE levels V and VI was even extensive thinning observed, with the inclusion of Alloy 25 AT's confirmed crack at level V.

continued

Figure 1: Graphical NACE MR0175 and ASTM G36 Boiling $MgCl_2$ Results

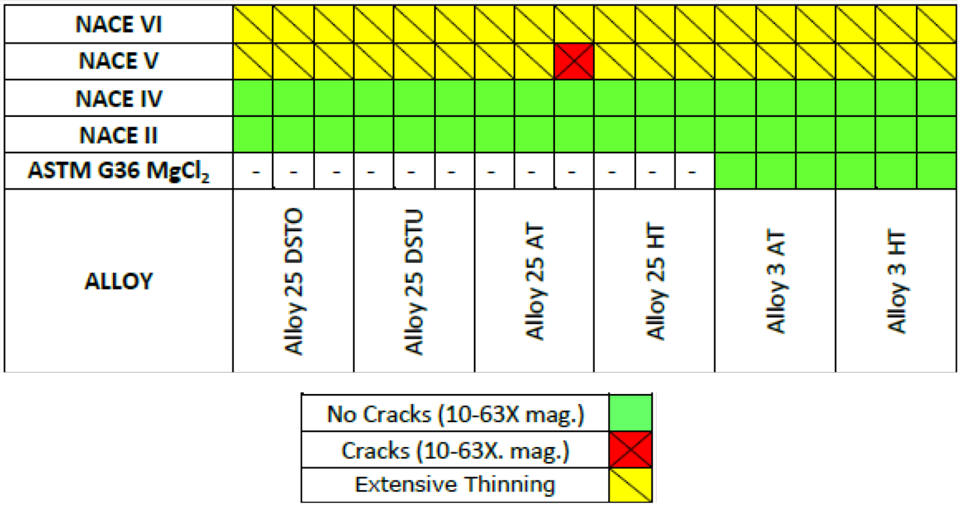
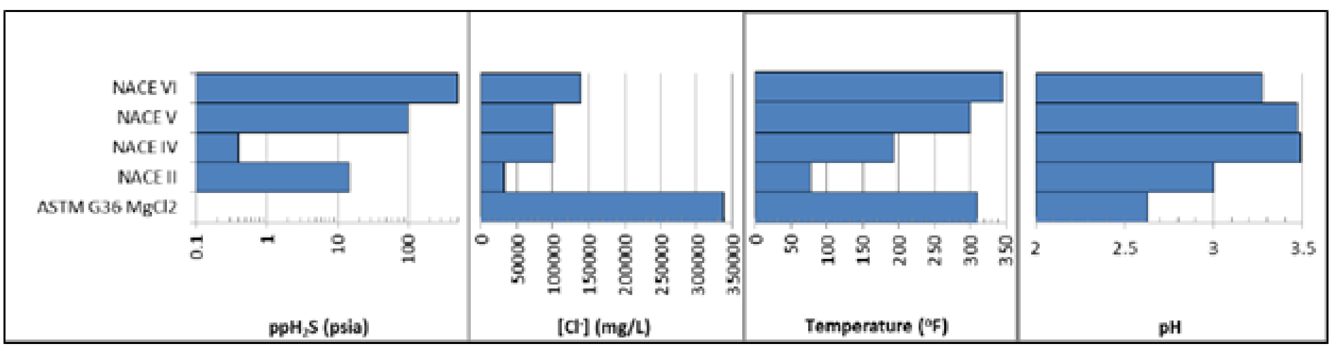


Figure 1 shows cracking results, where green represents materials that showed no cracking and red identifies the materials that did show cracking. The yellow results are those that displayed significant corrosion and specimen thinning, which may have reduced the imparted stress on the specimen since they were loaded into fixed-displacment fixtures.

Figure 2 shows the severity of the various environments in the testing: the left chart is partial pressure of H_2S in each condition; the left-center chart lists the calculated concentration of chloride ion from each test environment; the third chart lists the temperature of the test conditions; and the last chart on the right lists the pH of each test condition as calculated in OLI Thermodynamic software. For more information, see our white paper "Stress Corrosion Cracking / Sulfide Stress Cracking Testing in NACE MR0175 and ASTM G36 Environments of Copper-Beryllium Alloys."

Figure 2: Graphical NACE MR0175 and ASTM G36 Boiling MgCl2 Conditions



HEALTH AND SAFETY

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 the Materion Technical Service Department at +1-800-375-4205.