Elevated Temperature Cracking in Alloy C22

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Alloy C22 is the most corrosion resistant Ni-Cr-Mo alloy available today, and is particularly versatile. As a result, Alloy C22 is being considered for use in the construction of canisters for permanent disposal of radioactive waste in the Yucca Mountain Project. Unfortunately, limited weldability data on Alloy C22 is available to date. If proper precautions are not followed, both solidification-cracking and Ductility-Dip Cracking (DDC) may occur in austenitic alloys during fabrication involving welding. In order for Alloy C22 to be used within the Yucca Mountain Project, a high level of confidence about the weldability of this alloy must be obtained.

Solidification-cracking is a phenomenon caused by the application of weld shrinkage strains on locations that are liquated due to low melting liquid films resulting from partitioning during solidification. The solidification cracking susceptibility of Alloy C22 has been quantified using the Transvarestraint test. Ductility-dip cracking is a solid-state cracking phenomenon occurring below the effective solidus temperature of highly restrained austenitic alloys. The susceptibility of Alloy C22 to DDC will be quantified using the Strain to Fracture (STF) test, a Gleeble based test that provides information on crack initiation. The STF test results will be contrasted with results from the hot-ductility tests.

Initial Transvarestraint testing has been conducted on two heats of Alloy C22. Results indicate that Alloy C22 has a Solidification Cracking Temperature Range (SCTR) of approximately 48°C, which agrees with previously published data for similar alloys. Standard metallographic techniques revealed that cracking occurred along solidification grain boundaries and solidification sub-grain boundaries. Additionally, DDC was observed in some Transvarestraint samples that were subjected to high levels of strain; this cracking was confirmed to be solid-state through fractographic investigation. Initial STF testing was also conducted on the two heats of Alloy C22. A wide Ductility-Dip Temperature Range (DTR), and a low threshold strain (ε_{th}) indicate that Alloy C22 is susceptible to DDC. Additionally, unlike most alloys, Alloy C22 did not exhibit a ductility recovery at the upper end of the DTR. Hot-ductility testing of Alloy C22 base-metal and weld-metal was subsequently performed to provide contrast to the STF test results. Metallographic characterization of the Transvarestraint, STF, and hot-ductility test samples provides insight into the mechanisms behind solidification cracking and DDC in Alloy C22.

Initial testing indicates that Alloy C22 has a SCTR of approximately 48°C and is susceptible to DDC. Further testing and characterization of compositionally varied heats of Alloy C22 will allow for recommendations on minimizing or avoiding elevated temperature cracking of this alloy to be made.