Extended Abstracts
RE Einziger

Behavior of Stainless Steel in a Marine Environment

Mekonen Bayssie and Geoff Hornseth
SNF Storage & Transportation Division, US Nuclear Regulatory Commission
&
Leonardo Caseres
Southwest Research Institute

This paper discusses the susceptibility of welded and unwelded 304, 304L, and 316L austenitic stainless steels commonly used for dry storage containers exposed to marine environments to atmospheric stress corrosion cracking (SCC). Standard U-bend specimens were exposed to both salt spray and salt fog conditions at temperatures ranging from 25 to 176 °C,and varying relative humidity. The salt spray test scoped out material and residual stress effects. This deliberately conservative test resulted in extensive cracking and corrosion in all the 93 and 176 °C U-bend samples in as little as 1 month exposure. Salt spray tests are non-prototypical since deposition of salt on dry casks is in the form of a dry aerosol; hence, the test was not suitable for evaluation of SCC susceptibility of austenitic stainless steels in coastal atmospheres. The salt fog test, was expected to closely simulate field conditions around dry cask containers, and resulted in SCC and pitting corrosion in all the 43 °C specimens. Corrosion developed after 4 weeks in the 304 and 304L specimens, and after 32 weeks in the 316L specimen. This suggests that the alloy composition plays a role in SCC susceptibility. Cracking was mainly transgranular with sections of intergranular branching. Cracks were concentrated within the arch region in all unwelded U-bends and at the heat-affected zone of the welded specimens, as previously reported in the literature. None of the 85 and 120 °C specimens exposed to the salt fog test exhibited SCC; the data are consistent with the inability of salt deposits to deliquesce at high temperatures.

The tests indicate that chloride-induced SCC is highly dependent on the concentration of deposited sea salt, residual stress, cask temperature and the relative humidity of the surrounding environment. The results of the salt fog test may be conservative because the high absolute humidity used for the test was chosen to bound natural conditions expected in the dry storage cask environment. However, the results are still pertinent because they demonstrate that the deliquescence of dry deposited sea salt can lead to SCC of austenitic stainless steels at temperatures that are only slightly greater than ambient temperatures. The SCC acceleration factor used in laboratory testing and its implication on SCC initiation in actual dry storage cask units in the field are difficult to compute. Under the assumptions presented in this report, which simulate ideal conditions for the onset of SCC, initiation would be expected between 32 and 128 weeks. However, this is still a rough estimation because it does not take into account the operating history of the dry storage cask, and the local environmental properties at each cask location.