Steam Generator Analysis Confirms Low Probability of Cracking in Divider Plate Region

Physical and finite element analysis shows that stresses and bending loads are not sufficient to compromise the structural integrity of the steam generator channel head.

Primary water stress corrosion cracking (PWSCC) has been reported in the weld between the divider plate and the stub runner in French and Swedish steam generators with Alloy 600 divider plate material and Alloy 82 and 182 weld material. A 2010 EPRI analysis (1020988) concluded that it was not feasible for cracks to grow and propagate through the divider plate material and adjoining welds to the channel head and tubesheet structures because of the expected loading on the structure. The U.S. Nuclear Regulatory Commission (NRC) agreed with EPRI’s conclusions, but felt more analysis was needed with respect to long-term operations.

As part of license renewal applications, several U.S. plants committed to inspect for PWSCC in the divider plate assembly and in tube-to-tubesheet welds. NRC also issued guidance requesting that plants consider updating aging management plans to include divider plate and tube-to-tubesheet weld material. To inform regulatory and nuclear plant decisions regarding the safe extended operation of steam generators, EPRI initiated a follow-on project in 2011 to evaluate crack propagation to pressure boundary components such as the channel head or the tube-to-tubesheet weld.

The analysis investigated the following scenarios:

1. Crack propagation from PWSCC in the divider plate through the low-alloy steel – A fracture mechanics analysis using results from three-dimensional finite element modeling concluded that the stresses are not sufficient to propagate a crack over the life of the steam generator (at least 40 years) and compromise the structural integrity of the channel head.

2. Crack propagation from PWSCC in the divider plate to the tube-to-tubesheet weld - Finite element analysis determined that the dominant mechanical bending loads in the tubesheet-to-divider plate region are in the horizontal plane. The likelihood of these loads turning a crack vertical and causing crack propagation to the tubesheet weld – where it could compromise structural integrity – is low.

3. Crack initiation in the 82/182 cladding material or the tube-to-tubesheet welds – EPRI fabricated a tubesheet mockup to investigate the effect of chromium content on the integrity of tube-to-tubesheet welds. Results showed that chromium levels in the tube-to-tubesheet welds were sufficient to resist PWSCC initiation. Moreover, stress analysis of the center of the tubesheet – which uses 182 weld material and is most susceptible to PWSCC –
revealed that this material was in compression, meaning that the driving force for PWSCC initiation was not present.

Based on these results, current inspection programs are technically sufficient to ensure structural integrity of the steam generator channel head assembly. A final report (3002002850) was published in October 2014 and will be submitted to NRC for review by end of 2014.

For more information, contact Helen Cothron at 865.773.4033 or hcothron@epri.com.