SCC initiation in as-welded and thermally aged alloy 182 weld metal under simulated BWR/HWC conditions

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Several stress corrosion cracking (SCC) incidents occurred in alloy 182 RPV penetration, reactor internal attachment, and nozzle dissimilar metal welds in both boiling water and pressurized water reactors service in recent years that seriously challenged the integrity of the primary coolant circuit in some cases. Although the SCC rate is lower than under oxidizing BWR/normal water chemistry, it is still rather fast at low corrosion potentials under hydrogenated BWR/hydrogen water chemistry conditions and immediate repair or replacement of the component in case of a cracking incident may be necessary. Therefore, there is a need for further mitigation measures for critical dissimilar metal welds.

SCC initiation is strongly dependent on surface conditions (surface roughness, cold-work and residual stress, etc.) and several newly developed and suggested SCC mitigation methods are directly related to surface modification/optimization. Furthermore, short-range ordering (SRO) is a potential long-term thermal ageing (> 40 years) mechanism in Ni-alloys and weld metals that may increase their SCC susceptibility and decrease fracture resistance in the late stage of plant operation. SRO is the thermally activated formation of ordered regions (Ni_3Cr, Ni_3Fe, Fe_3Ni in alloy 182) in the few nm-range that act as obstacle for dislocation motion. This may result in an increase of yield stress/hardness and in more planar, localized plastic deformation that may increase the SCC susceptibility as well as in lattice contraction and an increase of local internal stresses/strains.

The influence of surface finish and thermal ageing on the threshold stress for SCC initiation in alloy 182 weld metal is currently being studied using flat tapered tensile specimens in simulated BWR/HWC water at 274 °C at the Ni/NiO phase transition boundary within framework of a new project at Paul Scherrer Institute. Thermal ageing was done at 400 °C for 800 h, 2400 h and 5500 h which (depending on the lower and upper bound activation energies for SRO in alloy 182 of 135 kJ/mol and 200 kJ/mol) would correspond to 10 & 11 years, 30 & 34 years and 70 & 78 years of reactor operation at 290 °C and 320 °C, respectively. The selected temperature is a reasonable compromise between acceleration of SRO ageing and moderate other microstructure modifications (carbide precipitation, recovery, etc.). This paper introduces this new project and discusses preliminary results about the potential effects of thermal ageing and surface finish on SCC initiation in alloy 182.