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Static strain aging of nodular cast iron

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ABSTRACT

EN-GJS-400-15U nodular cast iron that is intended to be used as load bearing element in long term geological disposal canisters containing spent nuclear fuel in Finland and Sweden was studied for static strain aging (SSA). SSA was studied by pre-straining tensile specimens manufactured from the nodular cast iron to 1%, 2% and 3% nominal plastic strains. The pre-strained specimens were then let to age at different temperatures ranging from room temperature (RT) to 400°C for varying times. After the aging treatment the specimens were tested with conventional tensile testing. Additionally, four specimens were studied with digital image correlation (DIC) during the tensile testing to obtain full field strain measurements. Strain aging was found to result in elevated and pronounced yield point in all the specimens for all tested pre-strain levels, temperatures and aging times when comparing to the as received material that originally behaved smoothly. The SSA was found to markedly reduced the elongation to fracture. No ductile to brittle transition was observed in the aged specimens and all the fracture surfaces showed signs of ductile dimpled fracture. Higher pre-strain levels resulted in increased yield strength levels in all aging conditions except at 400 °C at which inverse relationship was observed. The maximum yield stress values were achieved already after 1 day aging at 100 °C. The actual yield stress of the material was almost identical for 100°C and 200°C aging times and 11 day aging time at these temperatures seemed to have no effect on the upper yield strength. Aging at higher temperatures of 300 °C and 400 °C resulted in lower increase in yield strength and the yield point became less pronounced. DIC tests showed more localized yielding behavior in the strain aged specimens than in the as received specimen at the vicinity of the yield point. Strain aging was found to manifest as formation of complex Lüders bands at the onset of yielding. Formation of multiple bands inhibited the band propagation and lead to premature localization of strain in these areas which likely caused the reduced elongation.

Keywords: ductile cast iron, spent nuclear fuel, KBS-3, digital image correlation