Assessment of the resistance to stress corrosion cracking (SCC) of C-steel casing and overpack in a cementitious bentonite grout material

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The national agency for the management of radioactive waste (Andra) is in charge of the deep disposal of high level radioactive waste (HA). This waste is vitrified and confined in a stainless steel container itself introduced into a container (overpack HA) in carbon steel. These packages thus elaborated will be introduced into micro-tunnels drilled in the rock, cased with a low alloy steel pipe. Currently the concept includes the injection of a cementitious bentonite grout material between the casing and the rock to neutralize the potential acidity resulting from the excavation of the micro-tunnels and the gradual saturation of rock water. Due to the changing aeration conditions, it is necessary to study the steel corrosion behavior by taking into account the evolution of the expected redox potential in this system. The objective of this study is better understand the influence of the presence of this cementitious layer from the point of view of the sensitivity to stress corrosion cracking (SCC).

In order to identify the most critical potential range to initiate and propagate stress corrosion cracks, the Parkins approach was adopted, implementing electrochemical tests and potentiostatic tests under applied stress. The first step consisted in drawing polarization curves to define the most critical potential range for stress corrosion cracking. In regards to initiation, slow strain rate tensile tests (SSRT) with applied potential in a deaerated medium were carried out at a rate of $2.10^{-7}s^{-1}$ considered as sufficiently low to promote SCC. For the study of crack propagation, specimens of the fracture mechanics (CT specimen) were implemented with imposed displacement using dynamometric rings. For these tests, the samples were instrumented by electrical resistance monitoring to follow crack propagation.

With respect to crack initiation, 26 specimens were tested (X65-pipe material- and P285NH steel-overpack material-, base metal and weld) under different conditions. Only two of them (X65 steel) presented secondary cracks after failure. The microcracks observed were very few and thin, localized in the striction area, obviously associated to a very high value and high rate of plastic deformation.

Concerning the propagation tests at applied potential, in potential ranges similar to those used for the SSRT tests, the first results show the absence of sensitivity to propagation for the two steels studied. The experiments, lasting hundred of hours at each imposed potential, are still running.

These first results show that the selected steel grades for the casing (API 5L X65) and for the overpack (P285NH) do not exhibit any proven sensitivity to SCC, in the range of tested condition, with the used experimental methods. The testing program is still in progress to provide more results to assess the resistance of steel in various conditions expected in disposal conditions.