Corrosion kinetics of an API 5L X65 in contact with cement/bentonite at 40°C

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In the context of the French repository for high level waste, C-steel materials are currently considered amongst the most reliable materials for the prediction of long-term corrosion behaviour. They are foreseen for the casing and overpack, whose main functions are a sustainable mechanical resistance and water tightness during the thermal phase, respectively. The vitrified waste will be cooled in stainless steel containers encapsulated inside C-steel overpacks. The disposal cells, cased with C-steel will be horizontal (micro) tunnels drilled in the Callovo Oxfordian claystone (COx) at a depth of 500 m. A grout made of cement and bentonite will be injected between the casing and the host rock, in order to neutralise the potential acidity resulting from the pyrite oxidation due to the excavation work. The overpack and casing would be subjected to the evolution of the disposal cell from a thermo hydro chemical (THC) point of view.

In order to study the corrosion behaviour of the casing made of API 5L X65, an in-situ experiment was launched at the Meuse/Haute-Marne underground research laboratory. A 12 m deep borehole was drilled vertically in the COx claystone. Three electrochemical cells, each containing a working electrode (API 5L X65), a pseudo reference electrode (API 5L X65) and a counter electrode (INCONEL 625) were used to carry out measurements by the use of a Biologic potentiostat located in the research laboratory. A cement/bentonite grout material was injected to ensure a direct contact with both the borehole walls and the metallic electrodes and to represent the real repository conditions.

Linear polarisation resistance measurements, as well as voltammetry were conducted by scanning the potential at ± 15 mV and ± 50 mV around the open circuit potential (OCP) respectively. The first measurement (± 15 mV) provides polarization resistance values, which are then used to calculate the corrosion rate using Faraday's law. The second measurement (± 50 mV) provides information on the kinetics of the anodic and cathodic reactions of the system. The measurements were conducted at room temperature and 40°C. The results showed that after 3 years, the corrosion rate was below 10 µm/yr. The three investigated API 5L X65 electrodes revealed similar corrosion kinetics.

In perspective, the temperature will be increased to 70°C and then up to 80°C. Eventually, the equipment will be overcored (removed) in order to characterise the corrosion layers as well as perform mass loss measurements to determine the average corrosion rate.