Evaluation of monitoring techniques for localized and uniform corrosion of carbon steel used for radioactive waste disposal

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In the French Industrial Centre for Geological Disposal (CIGEO[1]), the French national radioactive waste management agency (Andra) has designed a multi-barrier concept for radioactive waste disposal. It is based on the confinement of the vitrified waste in a stainless steel container, itself introduced into an overpack in low alloy steel. These packages will then be introduced into micro-tunnels drilled in the rock, cased with a low alloy steel pipe. The casing is surrounded by a cementitious bentonite grout material, designed to neutralize the potential acidity, which results from the excavation of the micro-tunnels.

SCCoDRa (French acronym for “Monitoring of metallic components corrosion for radioactive waste disposal”) is a 4 year industrial project that focuses on the development of innovative corrosion monitoring tools for CIGEO, in order to detect and monitor the corrosion processes of the carbon steel casing foreseen in the High Level Waste facility (HLW).

As part of the SCCoDRa project, the first stage of the present work was devoted to review all the corrosion modes likely to occur over a period of a hundred years, corresponding to the operating phase of the HLW facility. Various phases are expected such as an acid transient, aerobic and anaerobic phases and progressive resaturation. The identified risks are: uniform corrosion under porous deposits, a more heterogeneous form of corrosion with proliferation of corrosion products, localized attacks exhibiting crevice and pitting features, galvanic corrosion, atmospheric corrosion, hydrogen embrittlement, stress corrosion cracking. Only the first three corrosion modes are investigated in the present work.

Specific experimental setups and procedures were designed in order to reproduce uniform and localized damages representative of the ones expected in the disposal concept, in terms of geometry and corrosion rates. Then, both acoustic emission and electrochemical techniques (open circuit potential, electrochemical noise, electrochemical impedance spectroscopy and linear polarization resistance) were tested as monitoring techniques. Their ability to detect and quantify corrosion damage was analysed at the laboratory scale. In a last stage, upscaling to a pilot scale and the potentialities of combining complementary methods will be studied.

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