# CORROSION CURRENT DENSITY EVOLUTION OF THE CARBON STEEL API 5L X65 IN CONTACT WITH NATURAL CALLOVO-OXFORDIAN WATER ASSESSED BY VARIOUS ELECTROCHEMICAL METHODS

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Cigeo is a future deep Nuclear Waste Disposal (NWD) facility for high-level and intermediate level long-lived radioactive waste, to be built in France, at 500 m depth within the clayey Callovo-Oxfordian formation (COx). Deep knowledge of the mechanisms and kinetics of corrosion occurring at the surface of tubings made of API 5L X65 carbon steel in contact with pore water of COx, is essential for a reversible NWD management of the site. This work aims to determine by various electrochemical techniques, the corrosion kinetics of the carbon steel X65 in contact with COx pore water flowing continuously through a multi-parameter probe (MPP), an innovative device for long-term monitoring, placed at 490 m depth for more than 156 days into a gallery of the Underground Research Laboratory of Andra at Bure, France.

A triplet, (X65 electrode - Ag/AgCl solid reference electrode - Pt counter electrode), is electrochemically monitored. Ag/AgCl(s) and Pt electrodes showed stability and robustness for over 156 days. Electrochemical Impedance Spectroscopy (EIS) measurements performed at Open Circuit Potential (OCP) of X65, allowed to identify a rather classic equivalent circuit model in water and showed that the corrosion is limited by the H+ reduction. Tafel plots and Voltammetric measurements around OCP and gave a Gary Stern parameter close to 15 mV, which used to determine the X65 corrosion current densities from the linear polarization resistances (LPR) obtained also by EIS. From 5 µA/cm² in the first hours, the current density decreases until day 5 to reach less than 1 µA/cm². The EIS analysis (Nyquist plot) revealed the appearance during this period of an increasing second loop at low frequencies, corresponding to a protective deposit on the steel surface. The current density then increases from day 5 to reach 10 µA/cm² (i.e. 120 µm/year on day 25). This period corresponds to the disappearance of the low-frequency capacitive loop in Nyquist plot, meaning that the deposit no longer protects the steel from corrosion.