Evaluation of Gas Transport Properties of Backfill Materials for Waste Disposal: H_2 Migration Experiments in Compacted Fo-Ca Clay

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Abstracts: Swelling clays may play a major role in the underground disposal of high-level nuclear waste (HLW) in deep geological formations. A multibarrier concept including a waste container, a steel overpack, an engineered barrier consisting of compacted clay (buffer) and the host rock is a potential technique for such HLW disposal. It is anticipated that H_2 will be the main gas generated, mainly by anaerobic metal corrosion during disposal lifetime. After complete resaturation, the clay barrier will have a very low permeability and H_2 may accumulate in the space between the overpack and the clay barrier. This could result in pressures exceeding the resistance of the clay and damage to the entire engineered barrier system (EBS).

The French Atomic Energy Commission (CEA) has performed an experimental program on H_2 gas migration in a French clay referenced Fo-Ca. The tests were conducted with a specific odometer-type cell developed by the Power Reactor and Nuclear Fuel Corporation (PNC) in Japan. Permeability tests on compacted Fo-Ca clay samples of specific dry densities between 1.6 and 1.9 and for water saturation degrees between 70 and 100% provided significant H_2 permeability data (ranging from 10^{-15} to 10^{-21} m^2). Gas migration experiments were also performed to study the behavior of Fo-Ca clay under high gas pressure. Two kinds of gas transport threshold pressures were detected in unsaturated compacted clay. The first one, called “ critical pressure ”, is the pressure over which a gas outflow migrates into the clay. This pressure probably exceeds the capillary pressure of the largest pores within the clay. The second one, called “ breakthrough pressure ”, is detected with increasing gas injection pressure. A sudden rise of gas outflow is subsequently observed. The occurrence of the gas breakthrough is associated with the aperture and propagation of preferential gas transport pathways in the clay. This is apparently linked to the hydromechanical properties and stress state of the clay. When clay samples are not fully watersaturated, the critical pressure is always lower than the breakthrough pressure. However, when the clay is saturated, the 2 pressures appear to be very close. Finally, this study showed that breakthrough pressure—a key parameter for the long-term stability of the clay buffer—varies considerably with the gas injection increments and with the size of the sample. The results of these experiments are consistent with those reported previously by other investigators.

Key Words: Density • Fo-Ca Clay • Gas Critical and Breakthrough Pressures • Gas Preferential Pathways • H_2 Migration • Water Saturation Degree

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