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Two-phase fluid flow calculations for a complex nuclear repository in a rock salt host formation

Ingo Kock and Martin Navarro
GRS gGmbH, Waste Management Safety Department, Germany (ingo.kock@grs.de)

Two-phase fluid flow calculations represent the state-of-the-art technique to study the transport of radionuclides regarding nuclear waste disposal and one tool to evaluate the long-term safety of nuclear waste repositories. We present results of a R & D project that has investigated two-phase fluid flow (e. g. gas and liquid fluxes) and radionuclide transport inside an existing repository for nuclear waste. Additionally, we study the transport of radionuclides out of the repository and the dependency of this process on factors, such as barrier corrosion and subsequent barrier failure.

For our study we selected the low-level/intermediate-level (LLW/ILW) waste repository “Endlager für radioaktive Abfälle Morsleben (ERAM)” in Germany, which lies in a shallow but complex salt structure. Currently, the ERAM is in the decommissioning phase and it is planned that most disposal areas are sealed with barriers of salt concrete and some with magnesia concrete. Salt concrete, which is not or only hardly compactable, is the intended backfill material for many of the remaining drifts and caverns. The shallow depth of the repository leads to low or perhaps even zero salt rock convergence. The combination of these features may cause pathways (e. g. the gap between roof and backfill) to only close slowly. Therefore, the hydraulic development inside the ERAM is of particular interest.

The two-phase fluid flow calculations were conducted using a code based on the TOUGH2 code of the Lawrence Berkeley National Laboratory (LBNL). We have added new processes to the code such as (i) a salt rock convergence, (ii) gas production due to material corrosion and water consumption, (iii) geotechnical barrier decay, (iv) time dependent permeability change and (v) transport and decay for radionuclide chains.

We have built three different repository models with varying level of complexity. For every model the same suite of calculations was performed. Altogether, about 700 deterministic and 400 probabilistic model runs were conducted. Deterministic model runs cover variations of all important aspects (e. g. barrier corrosion, barrier failure locations, backfill properties, hydraulic parameters, gas generation or rock salt convergence parameters) whereas the probabilistic model runs vary two-phase fluid flow parameters as well as drift and roof permeabilities.

The results show that, depending on model complexity, the time of complete corrosion of salt concrete barriers is heavily influenced by gas pressure due to gas generation and rock convergence. The time of the barriers' complete corrosion strongly controls the system behaviour as regards fluid flow and radionuclide transport. In general, parameters governing multiphase flow become more important with increasing model complexity.