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Treatment of uncertainties with respect to geomechanical modelling for proof of structural stability and integrity of the geological barrier of a radioactive waste repository in rock salt

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As one potential pathway for fluid migration/percolation, the geologic barrier has to be considered. In the case of rock salt, this pathway could become relevant, if certain geomechanical loading states and induced mechanisms apply, which lead to damage and loss of the initial tightness of the rock salt. These integrity-relevant processes are:
(1) the fluid-pressure-driven opening of grain boundaries, if the pressure exceeds the normal stress and adhesive forces at the boundaries, and/or
(2) generation and growth of (interconnected) cracks due to deviatoric loading.

To assess the geomechanical loading of the geologic barrier and its short and long-term evolution, numerical calculations are carried out. As a result of these safety analyses, a statement on the structural stability and barrier integrity can be given, using the conservative minimum stress criterion ("fluid-pressure-criterion") aiming at mechanism (1) and the dilatancy criterion aiming at shear stress-induced damage processes (2). Nevertheless, these results are more or less influenced by model assumptions, simplifications as well as data-, parameter-, and model-uncertainties and variabilities.

To treat these uncertainties of geomechanical modelling, a stepwise approach was used to show the range of possible solutions and to identify relevant issues and parameters. First, a catalogue of uncertainties was compiled after systematic screening of the whole modelling sequence from input data to output. The uncertainties and possible relevant issues identified cover categories, i.e. mine and geological/geomechanical model, backfill-planning, numerical code and model used, including its simplifications, boundary- and initial conditions, constitutive models and model parameters. If possible, these uncertainties were quantified and bandwidths were assigned. In a second step, the impacts of individual uncertainties on the barrier integrity were analyzed by sensitivity and bandwidth-studies. These studies use several generic models, each representative of specific conditions at different mine areas. The calculations evaluate the long-term evolution of the geomechanical state within the rock salt barrier; i. e., violation of fluid-pressure and dilatancy criteria as well as barrier thickness. This allows quantifying the impact of each uncertainty on the barrier integrity and identifying relevant uncertainties. In a next step, the relevance of these few issues will be checked on more realistic, comprehensive location-specific models by additional safety analyses. If the calculations performed will prove a relevant impact of uncertainties on the barrier integrity, further iterative steps become necessary to check if these uncertainty bandwidths can be narrowed down or have to be accepted and - if necessary - taking additional measures to narrow down these uncertainties.