Requirements on Sealing Measures Due to Gas Production

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Summary

Since 1981 the former rock salt mine Bartensleben near Morsleben (former GDR) ERAM has been in operation as a repository for low and intermediate level radioactive waste. As a result of the reunification and the changed licensing situation a new closure concept for the repository has to be developed.

During the post-opertional phase of a repository for radioactive waste gas may be produced by corrosion of metals, microbial degradation and radiolytic decomposition. In the process of developing the concept to be used for backfilling and sealing in ERAM it is important that gas formed in the repository will not disrupt the barrier against radionuclide escape or enhance the radionuclide release. To evaluate the performance and the properties for a bentonite plug as the main element of the sealings gas transport modelling with THOUGH were performed.

Due to the lack of site-specific data literature data were used. Consequently, large uncertainties in data remain at present, which were taken into account by a great number of parameter variations. To handle this a course discretisation for the calculations were developed. Started with a two-dimensional grid at the end the calculations were performed with a coarse one-dimensional grid.

The primary question to answer in these calculations is if there is a risk for excessive pressurization of the repository caverns as a result of gas generation. In the reference case a maximum pressure of approximatley 10 Mpa inside a cavern is reached after 1000 years which seems not to jeopardize the integritiy of the repository.

1. Gas production in the repository

The Federal Office for Radiation Protection in Germany (BfS) is required to submit before 1997 the basis for the legal procedure of authorising the plans for the operation of the repository for low-level radioactive waste at Morsleben, ERAM, in the German state of Saxony-Anhalt after the year 2000. The description of the planned backfilling and sealing measures forms the most important part of the documentation to be prepared and a basis for the long-time safety analyses.

During the post-operational phase gas will be produced inside the waste caverns by corrosion of metals, microbial degradation and radiolytic decomposition. This could impact the safety of the repository in different ways. Gas production could act as a driving force for brine flow, could enable radionuclide transport in the gaseous phase and could jeopardize the integrity of sealing measures.

To study the impact of gas production on sealing measures THOUGH gas transport calculations were performed for the actual most

3. Model implementation

The overall objective of the investigation was to determine the pressurization of the repository versus time, and the overall behaviour of the plug with respect to intrusion and discharge of brine. The exact definition of dimensions and properties of the plug are not finally decided so the geometrical representation of the Westfeld has greatly been simplified. A two-dimensional mesh, a coarse one-dimensional mesh and a detailed fine one-dimensional mesh have been used in the calculation. Figure 3 shows the layout of the model.

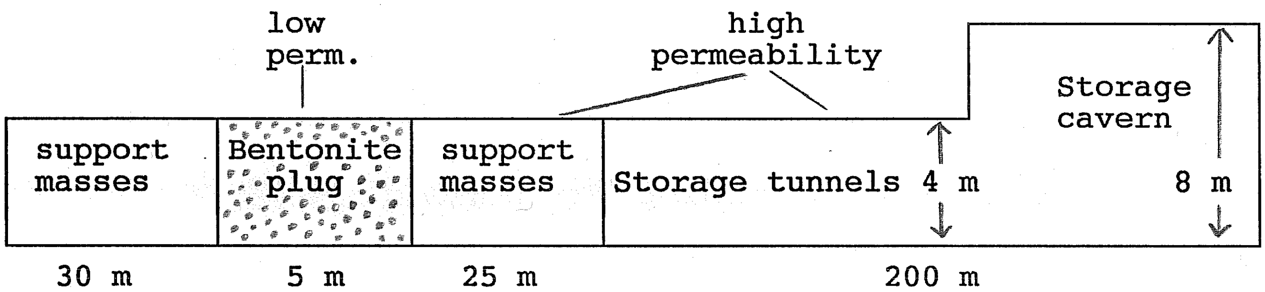

Fig. 3: layout of the numerical model

The THOUGH version 1 code was used on several 486 DX/50MHz PCs for the calculations. Different grids where tested for numerical convergence and precision. But for the essentially one-dimensional nature of the problem no differences were found between grids with 10 elements or 100 elements and one- or two-dimensional grids. For transient calculations from 0 to 10000 years the effective run times varied within the order of 1 hour for favourable cases and more than two weeks for combinations of high permeability and high capillary pressures.

4. Results

The calculations show that a total of 8 million m^3 of gas can be formed over a period of 5000 years. The maximum gas formation rate is estimated for 2400 m^3/year during the first 900 years.

For a plug permeability of 10^{-18} m^2 in the reference case the maximum pressure of 10,5 MPa, 5,5 Mpa in excess of the hydrostatic pressure is reached after 1000 years. An equilibrium between gas production and outflow exists between 2000 and 5000 years after closure. The maximum pressure of 6,5 MPa, 1,5 MPa in excess of hydrostatic pressure is in agreement with the critical gas pressure for the bentonite plug (see fig. 4).

With respect to more than 40 performed parameter variations pressurization of the Westfeld in excess of the lithostatic pressure has not to be expected for favourable cases.

Of particular interest is information on the amount of brine which at any point in time tends to be expelled form the repository by the gas. The expelled brine may be contaminated by radionuclides and therby contribute to the escape of radionuclides from the repository. From figure 5 it is clear that, for a permeability less 10^{-17} m^2, brine will not be pressed out of the repository at any time.

5. Conclusions and outlook

The issue of gas formation in a deep repository need to be seriously considered in an early stage of the conceptual work for the sealing measures.

The relative importance of the gas formation rate and the time for onset of full gas formation rate cannot be evaluated in a simple way. Large uncertainties are connected with the selection of the long-term corrosion rates. This is due to less well defined repository conditions in the post-operational phase and limited amount of data concerning corrosion rates measured under saline conditions. The uncertainties concerning the repository conditions include temperature, pH, as well as availability and quality of water. To reduce data uncertainties in the gas formation rates site-specific experiments have been set up.

The calculations need to be performed for a span of data to estimate the consequences of various parameter combinations. The calculations performed using a fully coupled brine and gas transport model show the need for a simplified model to be able to make calculations for a broad span of data. The use of a simple analytical model with the capability of handling the parameter combinations with a probabilistic approach is planned.

Due to the dry conditions in the waste caverns and the low iron content in the waste a low gas production is expected. Therefore closure of the waste caverns by tight sealings will not jeopardize the integrity of the repository by pressurization. The calculations as well indicate that brine will only flow into the repository, at least during the first 10000 years. The gas formation would not enhance the radionuclide release rate from the repository by expelling contaminated brine.

6. Literature

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Pusch R., Hökmark H. and Börgesson L., Outline of models of water and gas flow through smectite clay buffers, SKB Technical Report 87-10, Swedish Nuclear Fuel and Waste Management Co., June 1987

Pusch R. and T. Forsberg, Gas migration through bentonite clay, SKBF/KBS Technical Report 83-71, Swedish Nuclear Fuel and Waste Management Co., Dec. 1983

Pruess K., THOUGH User's Guide, Lawrence Berkeley Laboratory, LBL-20700, June 1987

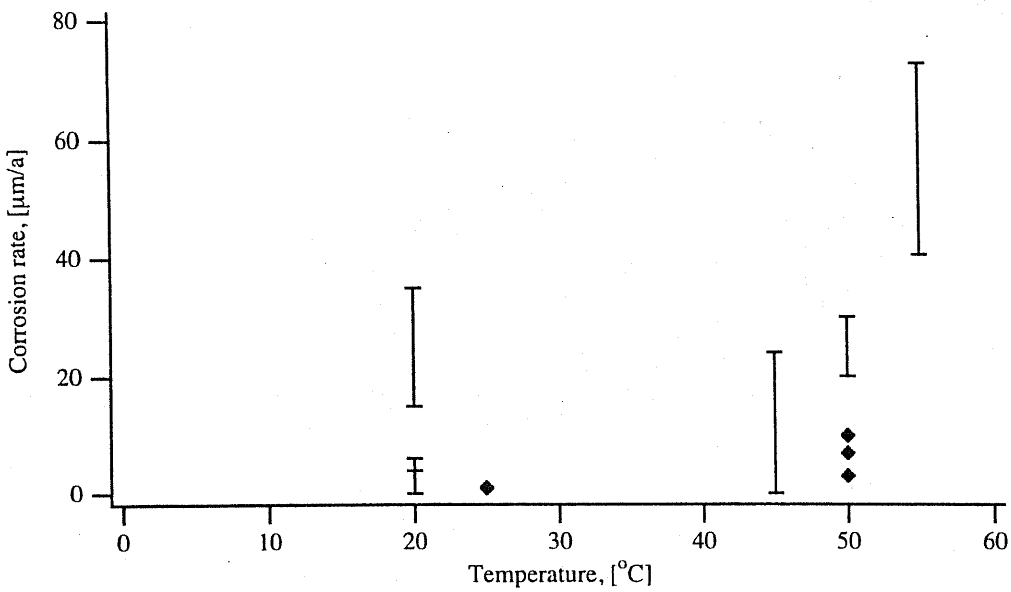

Fig. 1: corrosion rates for 0 - 60 °C

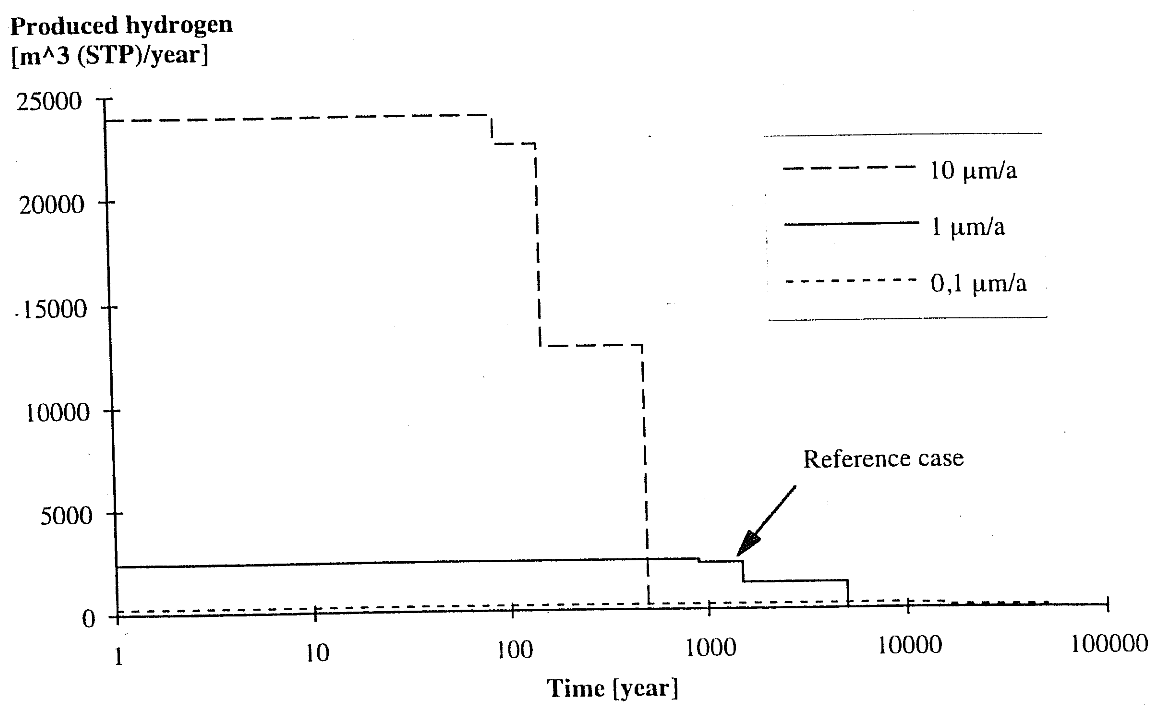

Fig. 2: amounts of hydrogen gas produced in the Westfeld as a function of time

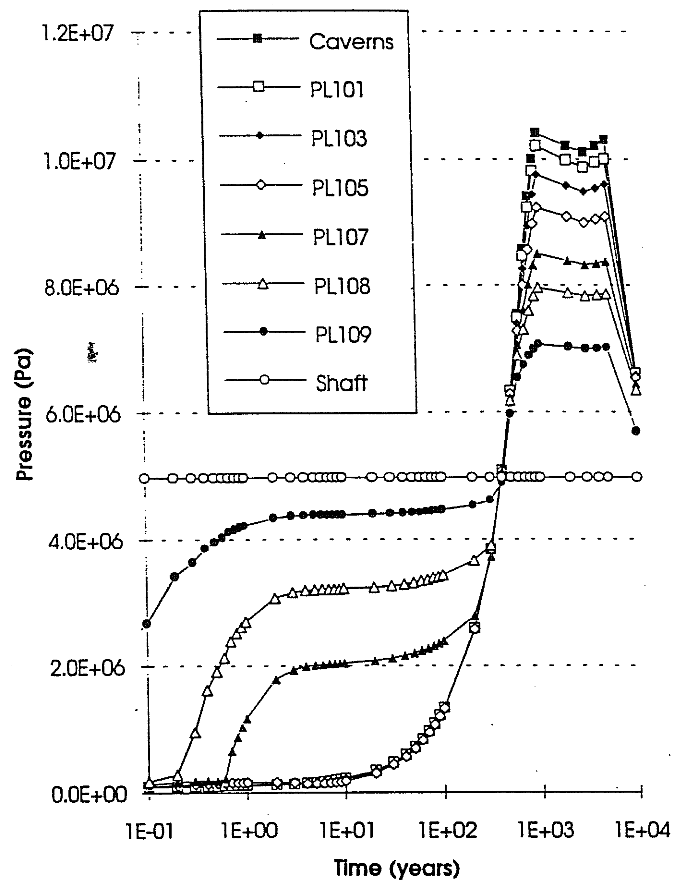

Fig. 4: prssure versus time in different elements

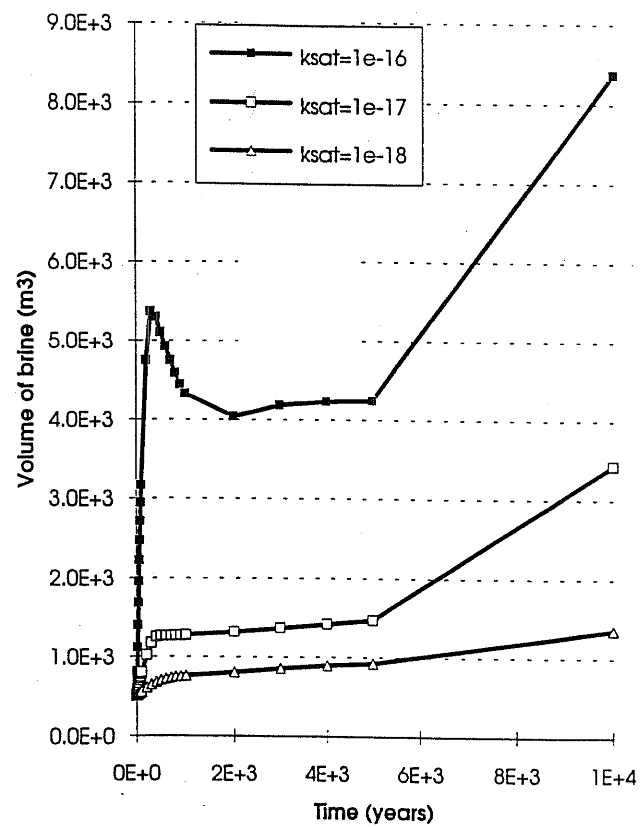

Fig. 5: variation of brine volume in the cavern versus time