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Research Report RR2009-01

Staßfurt Shallow Cavern Abandonment Field Tests

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EXECUTIVE SUMMARY

The Solution Mining Research Institute completed the multi-project research program „Cavern Sealing and Abandonment of Solution-mined Caverns in Salt Formations“ with a summary report in 2003. This research program enlarged the knowledge about the associated processes.

With reference to the results found within the completed research program the SMRI believed that the execution of field tests could validate the established theoretical background by long-term measurements and may advance the general understanding of all relevant physical and technical aspects.

The cavern abandonment field test at Stassfurt brinefield was performed at two shallow caverns (depth range between 400 – 500 m).

At one cavern (cavern S101) the observation of the previously measured pressure build up was continued. According to the intended test program the second cavern (cavern S102) has been pressurized up to almost the lithostatic pressure (related to the cavern roof) by brine injection.

At both test caverns the wellhead pressure was recorded over an observation period of 45 months.

As at the cavern S101 a continuous pressure build up was recorded the measured wellhead pressure of cavern S102 is mainly characterized by an initial pressure fall off followed by a long-term equilibrium, which was found 1.3 MPa below the lithostatic pressure at the cavern roof.

Within the performed test analysis all significant processes that contribute to changes in fluid pressure in sealed solution-mined caverns were considered providing the following main results:

- For the test caverns at the Stassfurt salt deposit salt/cavern fluid heat transfer can be excluded proven by the congruent temperature profiles logged prior to testing and after test completion (*subject to be confirmed*).
- In terms of additional salt dissolution it has been identified that the increased leaching potential forced by the rapid pressure build up will arithmetically lead to a comparable pressure fall off as expected from brine permeation at a transient rock stress state. However this inherent ambiguity is limited to a rather short time period (days or weeks) after cavern pressurization and does therefore not affect the brine permeation process at the found equilibrium.

- Salt creep has been analyzed by history matching the acquired pressure data applying rock mechanical models. Based on the analysis results it becomes evident that cavern closure at the found equilibrium pressure is very low, thus the respective brine flow rate which permeates the cavern wall must be equally small.
- The performed rock mechanical modeling shows different rock stress states around the cavern for the moment immediately after cavern pressurization compared to the found equilibrium pressure, which imply different salt permeability at the different rock stress states. The measured pressure response at the cavern S102 with gradually decreasing pressure fall off rates for the first 10 months of the observation period basically confirms the above mentioned assumptions.
- The estimated salt permeability at the equilibrium pressure is equal to the often applied initial permeability of $k_{ini} = 10^{-21}$ m² which indicates that the salt permeability does not necessarily need to be increased to reach a pressure equilibrium certainly lower than the lithostatic pressure. For the transient rock stress state a raised permeability of $k_{sec} = 10^{-20}$ m² is estimated and is therefore approximately one order of magnitude higher than the initial one. Taking into account that for the Stassfurt field test the difference in cavern fluid pressure immediately after cavern pressurization compared to the found equilibrium is limited to $\Delta p = 6$ bar the estimated permeability increase appears plausible.