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Coupled gas filling and flooding process of two caverns at the Lille Torup Gaslager (Denmark)

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Abstract

Gas Storage Denmark (GSD) operates a storage facility with seven gas storage caverns at the Lille Torup site in northern Denmark. The caverns have been built in the 1980s and after almost 30 years of gas operation GSD considered the flooding and recompletion of the caverns at Lille Torup. This project – especially the re-completion operation – was mainly motivated by safety reasons, i.e. installing state of the art equipment such as a surface controlled subsurface safety valve (SCSSV) and new sealing elements (packer). After having successfully completed flooding, recompletion and returning two caverns to gas storage, the brine discharge permit was surprisingly revoked. At this time the third cavern To-6 had been completely brine filled and already recompleted and was to be refilled with gas soon in order to return it to gas operation. However, with the revoked discharge permit for brine into the nearby fjord, alternative concepts for the gas filling operation of cavern To-6 had to be developed.

At the same time one of the other caverns, To-7, showed anomalous annulus pressures which gave reason to assume that an installed travel joint might have become untight. As an initial concept it was planned to use the brine from cavern To-6 to flood cavern To-7 in order to restore safe conditions for this cavern.

During the detailed engineering phase, this concept has been enhanced and was further developed. Additionally, to swap the brine from one cavern to the other, also the natural gas from cavern To-7 was intended for simultaneously gas filling cavern To-6 without processing the gas. This was to be realized via a direct coupling of the gas sides of the two caverns during the whole process.

The combined process of simultaneous gas filling and flooding of two coupled caverns was carried out in this form for the first time. The planning and implementation of the concept was accompanied by various and, in the case of cavern To-7, very cavern-specific issues and challenges. Basic aspects include the prevention of formation of gas hydrates, salt crystallization and the different pressure behavior of both caverns. Especially for flooding of cavern To-7, back-pockets in the cavern as well as previously injected Oppanol[1)] had to be additionally considered.

The project has been successfully executed between April and November 2019. In total, approx. 2.75 MM bbl (437,000 m³) of brine were pumped from cavern To-6 into cavern To-7 and, in the reverse, more than 2.8 bill. scf (80 million Nm³) of natural gas were injected from cavern To-7 into cavern To-6.

The paper gives an overview of the planning and implementation of the coupled process of flooding and gas filling and the associated challenges and insights. In particular, the interactions between the two processes are described. Additionally, the effects of cavern specifics are considered and presented.

[1)] Synthetic polymer of high viscosity and sticky consistency. Injected into gas storage caverns, in order to seal the cavern sump and thus, reduce the water content of the produced gas.

Key words: Brine Disposal, Cavern Hydraulics, Caverns for Gas Storage, Denmark, Flooding, Gas Fill, Instrumentation and Monitoring