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Volumes-Based and Mass-Based Distributed Temperature Sensing (DTS) Technology for Accurate Estimation of Nitrogen Leakage in Mechanical Integrity Tests

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Abstract

Existing cavern mechanical integrity test (MIT) practices are posing challenges in obtaining accurate calculated nitrogen leak rate (CNLR) due to the absence of reliable temperature measurements in wellbores. Accurate determination of CNLR is essential for ensuring safe operation of underground storage and/or disposal salt caverns. In this study, the distributed temperature sensing (DTS) technology is incorporated into an MIT system to improve the volume-based nitrogen leak rate calculation. Additionally, a new mass-based formulation developed for calculating the nitrogen mass leak rate (MLR) is introduced.

Next, this paper presents a computational fluid dynamic (CFD) model of an underground cavern with a wellbore that is 1,832 m (6010 ft) long created for simulating a nitrogen leakage at a minimum detectable leak rate (MDLR) of 80 m^3/year (2,825 ft^3/year).

The model allows the comparison of different methods for estimating CNLR, including i) conventional MIT without temperature effects, ii) MIT with temperature logging, and iii) MIT with DTS. Soave-Redlich-Kwong real gas model was implemented in the CFD model to describe the Nitrogen domain and accurately capture the compressibility effect in the numerical simulations. For this exercise, temperature measurements collected at a rate of 2 m per 12 seconds (10 m / min) was used to mimic actual temperature logs.

The comparison shows that the MIT with DTS method yields higher accuracy in estimating CNLR than the other two methods. In addition, the mass-based leak rate calculation provides a more robust way to determine leak rates when compared with volume-based methods.

Keywords: MIT (mechanical integrity test), calculated Nitrogen leakage rate (CNLR), solution-mined storage caverns, compressibility, distributed temperature sensing (DTS), temperature logging