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A Novel Method for Gas Cavern Mechanical Integrity Test Analysis

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Abstract

Solution-mined salt caverns are commonly used to store gases (natural gas, hydrogen, etc.) underground. Such caverns allow for large storage volumes and very high withdrawal and injection rates relative to their working gas capacity. In the US, Mechanical Integrity Tests (MITs) are conducted periodically to ensure that caverns are tight and can safely store the gas. Through this test, leakage is assessed to determine if the cavern is safe to operate, as a leaking cavern presents an unacceptable risk to the owner as well as the public. An MIT is executed by running pressure, temperature, and density logs in a cavern on two separate occasions. At the conclusion of MIT logging, a calculated leak rate (CLR), comparing the total gas volume at the test start and end is obtained along with an associated uncertainty known as the minimum detectable leak rate (MDLR).

In this paper a novel approach to gas cavern MIT analysis is proposed. This approach consists of two parts: (1) a standard CLR computation, with a revised procedure for the determination of the MDLR, and (2) an assessment of the temperature profile to identify temperature anomalies and potential casing leaks.

The uncertainty in the CLR depends on the accuracy of the measured quantities that are used in computing its value, including pressure, temperature, and interface depth. Current methods to compute the uncertainty results in high values of MDLR and consequently poor test accuracy. An alternative method to quantify the uncertainty is the "uncertainty propagation method," a statistical tool used to compute uncertainties in quantities that are not measured directly, but rather calculated through a set of measurands. In this paper, the uncertainty propagation method is applied to gas cavern MITs, in which the MDLR is obtained by combining the uncertainty in the directly measured quantities (i.e. pressure, temperature, and interface depth) used to compute the CLR. The second part of the MIT analysis includes an assessment of the temperature profile in the wellbore in steady-state conditions. The temperature profile is examined for localized cooling areas which could indicate expanding gas leaking behind or through the cemented casing.

This paper provides an overview of the typical US gas cavern MIT, together with the new proposed approach. Case study examples of natural gas storage cavern MITs are provided, comparing the traditional method to the proposed approach.

Key words: MIT, Gas Storage, Uncertainty Propagation, Error Propagation.