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A Liquid-Liquid Mechanical Integrity Test Analysis That Implements a Fluid Equation of State

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Abstract

Solution-mined salt storage caverns provide an efficient and cost-effective means of storing liquid hydrocarbons. Caverns are easily mined from salt using freshwater, and the impermeable salt provides an ideal storage medium. A Mechanical Integrity Test (MIT) is regularly conducted on the cavern system to ensure the continuing safety for hydrocarbon storage. The nitrogen-brine interface MIT is the North American industry's preferred method for testing a cavern casing shoe and wellbore. A liquid-liquid interface MIT provides an alternative test method when the nitrogen-brine interface MIT is not feasible. Factors that make a nitrogen-brine test impractical or impossible include limitations in the casing or wellhead pressure rating and the lack of a cavern neck where the interface can be placed for a short duration test.

It is common practice to use a liquefied petroleum gas (LPG) as the test fluid in liquid-liquid MITs (LL MIT). Widely practiced and accepted LL MIT methods assume a constant test fluid density. However, temperature and pressure changes during the test period may cause measureable density changes. A density change can lead to interface movement without an actual loss in test fluid volume. By using the measured surface pressure, down-hole temperature, and test media composition, the test fluid density may be estimated, which allows for a more accurate calculation of the change in test fluid volume during the MIT.

A new liquid-liquid, external well MIT method, based on the nitrogen-brine external well MIT, is proposed in this paper. This method accounts for test fluid density changes and, using a liquid hydrocarbon in place of nitrogen, applies the existing mass balance analysis of a nitrogen-brine MIT. In the mass balance, an algorithm that implements the most current thermodynamic and transport property models is used to calculate the test fluid density. This method provides a more robust analysis of cavern integrity in the well and cavern systems where density changes in the test fluid are significant during the testing period.

Key words: Caverns for Liquid Storage, Mechanical Integrity Testing, Liquid-Liquid MIT