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DIAGNOSIS OF LEAKAGE FROM UNDERGROUND STORAGE WELLS

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Abstract

Wellbore leakage at underground energy storage facilities poses potential environmental and economic risks. Fluids that leak vertically along wellbores typically cause sustained casing pressure (SCP)— a buildup of pressure in the annular spaces of the well at the wellhead. SCP is a key indicator of wellbore integrity issues that is relatively inexpensive to assess and provides valuable insight into wellbore leakage conditions. If left unmitigated, uncontrolled SCP can present safety hazards, potentially leading to negative impacts on operational safety and the surrounding environment. Therefore, there is a pressing need for theories, models, and tools specifically designed to analyze SCP data in underground storage wells.

This research introduces a novel modeling framework for simulating wellbore leakage in underground storage wells by analyzing SCP records. The model helps determine the flow mechanisms causing the observed pressure at the wellhead. It accounts for the non-linear flow dynamics that arise at higher pressures and flow rates, referred to as visco-inertial flow, typical in underground storage operations. Utilizing known inputs such as well configuration (e.g., casing depths, cement locations) and recorded wellhead pressures, the model estimates critical unknown characteristics of leaky wellbores such as the effective permeability of the compromised well element and the extent of leakage path.

The model was validated with SCP field data from a case study well. Results demonstrate the ability of the model to predict leakage behavior and estimate the effective permeability of the annular cement, correlating with the leakage path size behind the casing.

With further development and tuning based on data from various cases, this framework aims to provide a comprehensive and reliable tool for conducting risk assessments, predicting future leakage behavior, estimating the depth of leakage sources, and recommending effective repair methods.

Key words: Underground storage well, Wellbore leakage, SCP, Visco-inertial flow