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ASSESSING CASING DEFORMATIONS IN SALT CAVERN STORAGE WELLS USING MULTI-FINGER CALIPER DATA ANALYSIS

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Abstract

In salt cavern wells, excessive casing deformation or failure often occurs near the salt-caprock interface (cross-section ovalization and/or tensile parting due to shear deformation) and near the cavern roof (tensile parting due to cavern roof subsidence), posing a significant threat to wellbore integrity. It is postulated that such deformations/failures may be caused by salt creep. These deformations often progress over a period of years and, if not properly diagnosed and/or monitored, can compromise access to the cavern, leading to a loss of well barrier integrity, or resulting in early decommissioning of the well. Downhole casing inspection tools such as multi-finger calipers (MFCs) are regularly run at intervals to monitor storage wells for casing deformation, as well as internal corrosion in accordance with operators' due diligence and government regulations. Although traditional interpretation of MFC log data can determine the cross-section of the casing string, it does not provide an indication of the three-dimensional (3D) shape of the well. While tensile parting is readily identifiable from MFC measurements (i.e. sudden change in diameter greater than the outer wall and necking near the parting location), casing deformation in bending due to buckling and shear, and ovalization due to bending and collapse are difficult to diagnose and measure. To accurately differentiate among these deformation modes and quantify the severity, the casing 3D shape must be calculated. This can be achieved through specialized interpretation algorithms that use MFC measurements and the physical tool geometry to calculate the local changes in well trajectory. The results of this approach provide an indication of the nature and severity of the deformation, the rate of progression (when multiple MFC logs run over time are available), and the root cause failure mechanisms which can be used to assist evaluation of effective mitigation options. In addition, finite element analysis can be used to validate the casing deformation postulated based on MFC interpretation, to predict the rate of progression, and to propose the mitigation options.

This paper describes a summary of reported casing deformation modes in salt cavern storage wells, demonstrates how combining MFC log data with the physical tool geometry can be used to diagnose and quantify deformation characteristics (e.g. casing ovality, lateral offset, flexural strain), illustrates how deformation descriptions from multiple wells could be used to interpret broader movements throughout a salt dome or other geological structure, and displays how finite element analysis can be utilized to validate deformation hypotheses and provide insights into mitigation options. Two examples of deformations in oil and gas wells are presented to illustrate how this workflow can be used to assess the progression of casing deformations.

Key words: Wellbore Deformation, Casing Deformation, Multi-Finger Caliper, Shear, Buckling, Collapse, Parting, Well Integrity, Computer Modeling.