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Effect of the Addition of a Low Equivalent Stress Creep Mechanism to the Analysis of Geomechanical Behavior of the SPR West Hackberry Site

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Abstract

Sandia National Laboratories has long used the Munson-Dawson (M-D) model to predict the geomechanical behavior of salt caverns used to store oil at the Strategic Petroleum Reserve (SPR). Salt creep causes storage caverns to deform inward, thus losing volume. This loss of volume affects the salt above and around the caverns, puts stresses and strains on borehole casings, and creates surface subsidence which affects surface infrastructure. Therefore, accurate evaluation of salt creep behavior drives decisions about cavern operations. Parameters for the M-D model are typically fit against laboratory creep tests, but nearly all historic creep tests have been performed at equivalent stresses of 8 MPa or higher. Creep rates at lower equivalent stresses are very slow, such that tests take months or years to run, and the tests are sensitive to small temperature perturbations (<0.1°C). A recent collaboration between US and German researchers, however, recently characterized the creep behavior at low equivalent (deviatoric) stresses (<8 MPa) of salt from the Waste Isolation Pilot Plant. The M-D model was recently extended to include a low stress creep "mechanism". This paper details new simulations of SPR caverns at the West Hackberry site that use this extended M-D model, called the M-D Viscoplastic model. The results show that the inclusion of low stress creep significantly alters the prediction of steady-state cavern closure behavior and indicate that low stress creep is the dominant displacement mechanism at the dome scale. This paper also describes the changes to predicted stresses and strains that impact cavern and wellbore integrity. The results of the calculations in this paper indicate the need for laboratory creep tests at low equivalent stresses on salt from storage cavern sites. This knowledge will help to improve evaluation of storage cavern behavior in salt domes.

Key words: Caverns for Gas Storage, Caverns for Liquid Storage, Creep, Computer Modeling, Instrumentation and Monitoring, Rock Mechanics