Solution Mining Research Institute Fall 2019 Conference
Berlin, Germany, 23-24 September 2019

Investigation of pressure and temperature cycling influence on the stability of bedded salt caverns

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Abstract

An increasing number of salt cavern damage, cavern well damage, and even cavern failure has occurred over the past ten years. Many of these could have been anticipated and prevented with more complete geomechanical analysis and attention to appropriate operating practices for specific site conditions. Salt caverns in bedded formations in particular, are susceptible to large scale deformation and damage risk.

Most geomechanical studies and cavern stability analyses consider only long term steady state creep behavior of salt. But salt material is known to experience transient creep rates that are an order of magnitude or higher than steady state creep rate. Each time either the pressure or the temperature in a cavern changes (due to planned or unplanned operational changes), the salt experiences a period of renewed transient creep deformation. This can lead to larger than anticipated cavern deformation, closure, and damage that is rarely considered. The effects can be particularly important in bedded caverns with larger diameter to height ratio.

Numerical investigations are completed on a range of salt cavern configurations, a range of salt material behavior, and a range of pressure and temperature cycling conditions. Accelerated deformation is shown to occur due to both periodic changes in pressure and temperature, with the rate of deformation primarily controlled by stress difference, temperature rate change and cavern height to diameter ratio. The current investigation and research examines and documents these effects, providing insight and guidelines for safer salt cavern operations.

Key words: rock salt, gas storage, bedded salt caverns, cyclic loading, rock mechanics, high frequency