Rock Mechanics For Underground Storage

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INTRODUCTION

The utilization of underground storage systems has substantially increased in the past 20 years. A substantial portion of the storage space has been developed in bedded salts or salt domes to take advantage of the "self-healing" properties of salt materials at relatively large depths. The development of deeper and more sophisticated storage spaces has resulted in the need to evaluate more precisely the structural behavior of the openings, specially the magnitude and rate of creep of natural rock salt at relatively constant temperatures for long periods of time. The financial and environmental incentives to operate the caverns using the "dry method," where no brine is injected to replace product during withdrawal, have triggered the need to estimate the potential loss in storage volume through the life span of the cavern as a function of the cavern spacing and the range of operating cavern pressures.

The author has been responsible for the analysis of the rock-mechanics related aspects of several existing storage facilities as well as for the design aspects related to the development of large (700,000 barrels) underground cavities in bedded salt deposits ranging from 3000 to 6000 ft deep. In addition to the need to determine the overall structural behavior of the proposed caverns, it was also necessary to estimate the potential loss of cavern storage volume through the intended life span of the project. The rather limited amount of published information regarding long-term cavern behavior; and the shortcomings inherent in extrapolating such behavior from lab tests, led to the performance of a large in situ test that lasted for almost one year (320 days). This paper summarizes the results obtained from this test and provides an analysis of the structural behavior of storage caverns taking into account the long-term creep behavior of the salt materials under various stress levels. Finally, the paper provides design guidelines for development of storage caverns in salt deposits, incorporating the observed structural performance of various successful as well as problem storage cavities. Although the design approach presented here was focused on storage caverns in salt deposits, the basic modes of failure evaluated as well as the basic principles considered are applicable for underground storage in any other rock materials.