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**Experimental Assessment of Effective Tensile Strength of  
Rock Salt and Infiltration Fracture Behavior  
in Salt Caverns during Gas Operation**

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## EXPERIMENTAL ASSESSMENT OF EFFECTIVE TENSILE STRENGTH OF ROCK SALT AND INFILTRATION FRACTURE BEHAVIOR IN SALT CAVERNS DURING GAS OPERATION

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### Abstract

The geomechanical design of a gas storage cavern requires the determination of the maximum and minimum internal pressures, as well as the injection and withdrawal rates. These parameters are essential for ensuring geomechanical stability and operational safety. During gas withdrawal, the surrounding rock cools due to gas pressure reduction and gas temperature decrease, leading to thermally induced stress reduction in the rock mass. This can temporarily lead to effective tensile stresses on the cavern wall, which can cause infiltration fractures if the existing gas pressure exceeds the smallest compressive stress component plus the effective tensile strength of the rock salt.

To evaluate the effective tensile strength of rock salt, a laboratory program was developed to evaluate the rock salt behaviour under effective tensile stresses. Therefore, a series of specifically designed mechanical extension experiments under gas pressure and different boundary conditions (variation of the test temperature, the initial pressure and the pressure rate on test specimens from different locations) were carried out in the laboratory to simulate the stress conditions occurring in a gas storage cavern during the gas withdrawal phase.

A numerical sensitivity study then integrated the experimental results and investigated the influence on the infiltration fracture length and its distribution using the infiltration fracture approach for a total of three experimentally selected effective tensile strengths and five defined fracture line distances. The infiltration fracture approach is an engineering approach for evaluating the effective tensile stresses on the cavern wall that occur mainly during the gas withdrawal phase.

The experimental results showed that a pressure difference between higher gas pressure and minimal pressure component from 0.99 MPa (143.59 psi) to 4.87 MPa (706.33 psi) was required before macroscopically visible fractures appear. The magnitude of the pressure difference depends in particular on the location, which corresponds to different salt characteristics and textures.

The results of the numerical sensitivity analysis show that the decisive infiltration fracture length should be determined from the mean value of the infiltration fracture length of the modelled fracture lines. This applies to a small rock area (here with 5 defined fracture lines) when a defined fracture line distance is considered, at which the individual fracture lines have a negligible influence on each other (here greater than 1 m), in order to describe the general infiltration fracture behaviour at the cavern wall. Taking different values for the effective tensile strength into account has no significant influence on the determined infiltration fracture length for the selected seasonal load case scenario and the generic cavern in a salt dome.

**Key words: Underground gas storage, Infiltration fractures, Effective tensile strength, Effective tensile stress, Rock salt, Salt caverns**