

## ABSTRACT

The concept of chilling gas to dramatically increase the working gas capacity of a given storage volume may be applicable to planned or existing salt storage caverns. Facilities in bedded salt are of particular interest for expansion by chilled gas storage because the salt stock and brine disposal capacity at these facilities are often limited, making expansion by mining of additional caverns uneconomical. Thus a study, sponsored by the U.S. Department of Energy's National Energy Technology Laboratory, has been undertaken to examine the feasibility of storing chilled natural gas in salt caverns. The study requires numerical simulation of the thermomechanical response of the caverns, which in turn, requires a laboratory study to determine the thermal conductivity of the salt and the effect that changes in temperature have on the mechanical properties of the salt. The range of temperatures investigated in the laboratory extends from the stored gas temperature ( $-30^{\circ}\text{C}$ ) to ambient salt temperatures (up to  $40^{\circ}\text{C}$ ).

Radial heat flow tests were performed on salt at different temperatures over the  $-30^{\circ}\text{C}$  to  $40^{\circ}\text{C}$  range to determine the effect of subambient temperatures on thermal conductivity. The specimen used for the radial heat flow tests was a 200-millimeter-diameter cylinder, which reduced the effect of the small 6-millimeter-diameter cartridge heater along the specimen axis to a line source. The thermal conductivity of the salt increased by nearly 60 percent as its temperature decreased from  $40^{\circ}\text{C}$  to  $-30^{\circ}\text{C}$ , following a power-law relationship with temperature.

In addition to the thermal conductivity testing, mechanical properties tests were performed on 100-millimeter-diameter cylinders over the temperature range to determine how strength and deformation properties changed with changes in temperature. The mechanical tests included: (1) constant strain rate, triaxial compression tests to evaluate strength and elastic moduli, (2) constant mean stress tests to evaluate the dilatancy limit, and (3) constant stress creep tests to evaluate the time-dependent deformation rates at low temperature. Test procedures and equipment are described for all tests. Test results are presented to illustrate how reductions in salt temperature affect its thermal and mechanical properties.

## INTRODUCTION

### Background

The concept of chilling gas to dramatically increase the working gas capacity of a given storage volume may be applicable to planned or existing bedded salt storage caverns. Facilities in bedded salt are of particular interest for expansion by chilled gas storage because the salt stock and brine disposal capacity at these facilities are often limited, making expansion by mining of additional caverns uneconomical. A recent study by PB-KBB Inc. [1998] determined that it may be feasible to store chilled natural gas in a mined hard-rock facility. However, the