Objectives of Exploratory Studies Facility (ESF) Thermomechanical Experiments

• Verify fundamental physical model assumptions about the coupled thermal and mechanical behavior of the host rock

• Measure the thermal and mechanical properties of the rock mass

• Provide measured data to validate computer models of the rock mass

• Investigate stress-induced changes in fracture apertures of the rock mass
Objectives of Exploratory Studies Facility (ESF) Thermomechanical Experiments

(Continued)

• Demonstrate the effects of high temperatures on repository-scale volumes of rock

• Provide data on stability of emplacement boreholes and drifts

• Evaluate the effects of thermal loads on ground-support systems

• Confirm design concepts proposed for the potential repository
Approach to Meeting Information Needs

The objectives will be met by four experiments of increasing complexity and scale:

- Heated-block experiment
- Canister-scale heated borehole experiment
- Thermal stress test
- Heated-room experiment
Heated Block Test

- Slot
- Heater
- 2 m

Typical Joints

1 m X 2 m Flatjack
Heated Block Test: Objectives

- Measure thermal and mechanical properties
  - Deformation modulus and Poisson's Ratio
  - Coefficient of thermal expansion
  - Thermal conductivity and heat capacity

- Code validation

- Verify physical models

- Stress-induced changes in fracture aperture
Canister-Scale Heated Borehole Experiment
Canister-Scale Heated Borehole Experiment: Expected Temperatures

![Graph showing expected temperatures in a canister-scale heated borehole experiment. The graph illustrates the temperature distribution as a function of radial and axial distance. Temperature values at different points are labeled as A = 35.0, B = 50.0, C = 80.0, D = 100.0, E = 150.0, and F = 300.0 degrees Celsius.]
Canister-Scale Heated Borehole Experiment: Notes

Objectives

• Measure thermal and mechanical properties
• Validate computer models
• Evaluate borehole stability
• Design confirmation

May be dropped if drift emplacement is used

Could be used to evaluate different waste-emplacement modes
Thermal Stress Test

LEGEND
- Thermocouple
- Stress Gauge
- Multiple-Point Borehole Extensometer Anchor (MPBX)
- Long-Gauge Surface Extensometer (SX)
- Cross-Drift Wire Extensometer Anchor (CDX)
- MPBX Instrument Head
- Heater
- Insulation

Invert Shape TBD

SCALE (ft)
Thermal Stress Test
Projected Temperatures

Temperature Contours at 90 Days of Heating
Thermal Stress Test: Notes

Objectives

- Measure thermal and mechanical properties
- Validate computer models
- Evaluate drift stability
- Evaluate effect of heat on ground support

Used to investigate rock-mass strength

Temperatures and stresses will exceed expected repository conditions
Heated-Room Experiment

HEATER ACCESS DRIFT

TYPICAL HEATER ARRANGEMENT

THERMAL BARRIER

MPBX = MULTIPLE-POINT BOREHOLE EXTENSOMETER
LGSX = LONG-GAUGE SURFACE EXTENSOMETER

HEATED ROOM

(BEST AVAILABLE COPY)

DCESFTJP12.125.NWTRB/7-13/14-93
Heated-Room Experiment
Projected Temperatures

POWER = 90 kW

TEMPERATURE (°C)

A = 32.0
A1 = 36.0
B = 60.0
C = 100.0
D = 200.0
E = 300.0
F = 400.0

X (m)

Y (m)
Heated-Room Experiment: Notes

Objectives

• Evaluate repository-scale drift stability under elevated temperatures and stresses

• Measure rock-mass thermomechanical properties

• Code validation

• Ground support under elevated temperatures

Will be integrated with LLNL hydro-thermal experiment
## Proposed ESF Tests and Their Objectives

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Heated Block</th>
<th>Canister-Scale Heated Borehole</th>
<th>Thermal Stress</th>
<th>Heated Room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measure thermal and mechanical properties</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Evaluate effect of heat on large rock volumes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
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<tr>
<td>Verify physical models</td>
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<td>Yes</td>
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<td>Yes</td>
</tr>
<tr>
<td>Validate computer models</td>
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<tr>
<td>Evaluate borehole stability</td>
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<td>No</td>
</tr>
<tr>
<td>Evaluate drift stability</td>
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<td>Evaluate effect of heat on ground support</td>
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<td>Design confirmation</td>
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<tr>
<td>Stress-induced changes in fracture aperture</td>
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</tbody>
</table>
Conclusions

ESF thermomechanical tests

• Support evaluations of retrievability by
  - Evaluating drift and borehole stability
  - Validating computer codes

• Will obtain information for all potential thermal-loading scenarios

• Will support any waste-package emplacement scheme