NUCLEAR WASTE TECHNICAL REVIEW BOARD
FULL BOARD MEETING

SUBJECT: IN SITU THERMAL AND MECHANICAL TEST PROGRAM

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WASHINGTON, D. C.
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OVERVIEW

- Objectives
- Requirements/Information Needs
- Proposed Revised Test Program
- Conclusions
OBJECTIVE

Develop a revised in situ test program that

1. Will address the specific Information Needs to a level of confidence to support the stepwise decisions inherent in the Program Approach.

2. Can be accomplished in a limited time frame to support technical site suitability and the initial License Application.

3. Will be limited in scope and focus on preclosure issues, while forming a basis for additional testing that will be required for later licensing decisions.
REQUIREMENTS/INFORMATION NEEDS

Design — Title I Design for Initial License Application

- Rock-mass thermal properties and thermal expansion
- Rock-mass mechanical properties *
- Rock-mass scale fracture * properties
- Rock-mass strength *
- Material interactions *
- Thermal response of drifts – model validation

*at ambient and elevated temperature
REQUIREMENTS/
INFORMATION NEEDS
CONTD.

Preclosure Performance Assessment

• Rock-mass thermal properties and thermal expansion

• Rock-mass mechanical properties *

• Rock-mass scale fracture properties *

• Rock-mass strength *

• Operation phase drift and intersection stability

• Temperature effects on rock thermal and mechanical properties

*ambient and elevated temperature
Silica Phase Transformations (Near-Field)

Temperatures at which inversions occur are a function of previous temperature cycling (150 to 170°C for Tridymite) (170 to 200°C for Cristobalite).

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Silica Phase Transformations are not a Design or PA issue.

Are Tridymite and Cristobalite Present?

NO

Silica Phase Inversions and Reversions are not a Design or PA issue

YES

Are Predicted Temperatures Greater than Tridymite Inversion Temperature?

NO

Are Predicted Temperatures Greater than Cristobalite Inversion Temperature?

YES

Is Failure in Drifts/Accesses Predicted Due to the Cristobalite and/or Tridymite Inversions?

NO

Silica Phase Inversions and Reversions are not a Design or PA issue (Reversions must still be evaluated)

YES

Can These Failures Be Mitigated by a Change in the Ground Support System?

NO

Are There Any PA Implications to the Tridymite Inversion?

YES

Reduce Temperatures: Reduce Waste Package Capacity Alter Spacings (APD) Change General Layout

Silica Phase Inversions are not a PA issue--Evaluate Reversions Prior to Making Design Changes

NO

Are There Any PA Implications to the Change in Ground Support or to the Tridymite Inversion?

YES

Reduce Temperatures: Reduce Waste Package Capacity Alter Spacings (APD) Change General Layout
Determination of Backfill Properties

Is There Shedding From One Panel/Drift to Another?

Is the Shedding Detrimental?

Can a Backfill Be Designed to Act As a Capillary Barrier?

Are There Any Negative PA Implications Related to the Proposed Capillary Barrier?

Is the Shedding to Empty Spaces Between Panels/Drifts?

Do Empty Spaces Shed to Panels/Drifts as the Temperature Decreases?

Will Increasing the Thermal Loading Eliminate the Shedding Issue?

Will Decreasing the Thermal Loading Eliminate the Shedding Issue?

Evaluate Decrease in Loading with Respect to Other Design and PA Issues

Evaluate an Increase in Loading with Respect to Other Design and PA Issues

Add Capillary Barrier Design to Overall Repository Concept

Evaluate Decrease in Loading with Respect to Other Design and PA Issues
Excerpt From Thermal Loading Decision Tree (Pre-Closure)

1. Is time, t, greater than closure time?
   - YES
   - NO

2. Stability of Access and Intersections
   - Are Emplacement Drifts Stable?
     - YES
     - NO

3. Can Ground Support be Increased to Ensure Stability?
   - YES
   - NO

4. Can Periodic Maintenance Mitigate Stability Issue?
   - YES
   - NO

   Evaluate a Change in Thermal Loading to Allow for Retrieval Option

5. Are There Any PA Implications to the Change in Ground Support?
   - YES
   - NO

   Evaluate a Change in Thermal Loading to Allow for Retrieval Option

6. Can Drift Be Cooled to Operational Limits?
   - YES
   - NO

   Are there any PA or Design (T-M) issues Related to the Cooling of the Drifts?
   - YES
   - NO

   Evaluate a Change in Thermal Loading to Allow for Retrieval Option

Confidence in T-M models
Models of jointed-rock behavior
Accurate T-M properties
Effect of T-C on Mechanical Response
Silica Phase Inversions
Waste Package — Title II Design

- Rock-Mass thermal properties (including backfill)

- Near-field environment – focus on containment period

- Drift stability under thermal loads – focus on containment period
REQUIREMENTS/
INFORMATION NEEDS
CONTD.

Postclosure Performance Assessment “Bounding” estimates

• Rock-mass thermal properties

• Temperature effects on rock mass thermal and mechanical properties

• Hydrologic properties – ambient and disturbed conditions

• Conceptual model/hypotheses testing — T-M-H-C coupling
  – heat transfer
  – vapor movement
  – fracture flow
## SUMMARY OF INFORMATION NEEDS AND CUSTOMERS

<table>
<thead>
<tr>
<th>Information Needs</th>
<th>Design</th>
<th>Pre PA</th>
<th>Post PA</th>
<th>Waste Pack</th>
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<td>Yes</td>
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*Properties needed as a function of temperature
OTHER CONSTRAINTS

- Time
- Location
- Construction Methods
PROPOSED TEST PROGRAM

- Axisymmetric Heater Tests
- Heated Block Test
- Thermal Stress Test
- Plate Loading Test
## SUMMARY OF INFORMATION NEEDS AND TESTS

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AXISYMMETRIC HEATER TEST

- Thermal Properties — TSw 1 and TSw 2
- Model Validation — thermal and coupled T-H
- Permeability changes
- Drying front
- Fracture flow
- Horizontal and vertical configurations
- Ideal geometry
Schematic View

10-point axial thermocouple probe

Power Monitor

Tuff container

Heater

Insulation

7-point radial thermocouple probe

r = 20 in.

7 ft.
Axisymmetric Heater Test
Horizontal Configuration (plan view)
HEATED BLOCK TEST

- Controlled boundary conditions
- Fracture properties
- Rock-mass deformation and strength
- Model validation coupled T-M-H effects
- Thermal expansion of rock mass
THERMAL STRESS TEST

- Demonstration of rock-mass behavior on emplacement room scale
- Simulates in-drift emplacement problem
- Thermal overdrive
- Short time scale
- Rock-ground support interaction
THERMAL STRESS TEST CONT'D.

- Geochemical effects of manmade materials
- Near-field environment during containment period
- Room-scale conceptual model validation for T-M-H processes
- Thermal and mechanical effects on rock-mass permeability
Thermal Stress Test

LEGEND
- Thermocouple
- Stress Gauge
X 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)
SUMMARY AND CONCLUSIONS

- Test program is being modified to meet the needs of the Program Approach

- Additional testing will be required to support later licensing decisions
SUMMARY AND CONCLUSIONS CONT'D.

- The proposed thermal/mechanical tests will provide

  1. The data and information needs required by the PA for site suitability and the initial License Application.

  2. Can be fielded within the allowable time windows to provide the information for technical site suitability and the initial License Application.

  3. Are simple and flexible enough to fit within the construction and operational constraints of the ESF during early construction period.

  4. Are consistent with the SCP performance allocation process and will directly feed the thermal-load decision process.