ENCLOSURE

Summary Highlights of NRC/DOE Technical Exchange Meeting on Repository Design and Thermal-Mechanical Effects Key Technical Issue

May 6-8, 2003
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange Meeting on Repository Design and Thermal-Mechanical Effects (RDTME) is one in a series of meetings related to the U.S. Nuclear Regulatory Commission (NRC) and U.S. Department of Energy (DOE) key technical issue (KTI) resolution process. The NRC and DOE held a Technical Exchange Meeting on DOE's approach to addressing the RDTME KTI Agreements. Consistent with NRC regulations on prelicensing consultations and a 1999 agreement with the DOE, staff-level resolution can be achieved during prelicensing consultation. The purpose of issue resolution is to assure that sufficient information is available on an issue to enable the NRC to docket a proposed license application. The discussions recorded here reflect NRC's current understanding of aspects of RDTME KTI most important to repository performance. This understanding is based on all information available to date which includes limited, focused, risk-informed reviews of selected portions of recently provided DOE documents.

The objectives of this meeting were to: 1) review and discuss the geological, rock properties testing, and modeling work conducted in the past year aimed at resolution of RDTME KTI Agreement items; 2) receive NRC feedback on DOE's resolution strategy and adequacy of data and modeling conducted thus far; and 3) define the path forward on any remaining information needs prior to license application submittal. The Agenda for the meeting and the List of Attendees are Attachments 1 and 2, and the DOE presentations are Attachment 3.

Highlights of DOE Presentations

1) Opening Comments

Mark Board (Bechtel-SAIC Corporation, BSC) presented "Review RDTME Resolution Strategy and General Overview of Work Completed on This Strategy to Date." He: (i) reviewed the basic site geology and proposed repository layout; (ii) discussed issues specific to non-lithophysal versus lithophysal rocks; (iii) summarized the basic geomechanical issues as a subset of RDTME KTI; (iv) summarized the resolution strategy; and, (v) introduced the rest of the presentations. Mark Board stated that the ground support system would be designed to last at least 75 years with minimum maintenance. Additionally, an appropriate maintenance program would be developed if the preclosure period is extended.

2) Geological Analysis

A summary of the current status of the geologic analysis was presented [see attached "Review of Fracture Mapping and Analysis Studies for Input to Rock Modeling" by Robert Lung (US Bureau of Reclamation) and Mike Fahy (US Geological Survey); and "Review of Lithophysal Mapping Studies and Analysis" by David Buesch (USGS)].

Review of Fracture Mapping and Analysis Studies for Input to Rock Modeling

Robert Lung (USBR) presented the review of fracture mapping and analysis studies that have been conducted to provide input to rock modeling. He presented DOE's approach for non-

lithophysal rocks which includes generation of fracture networks using the FRACMAN code. As an example, he presented the fracture network generated for the lower lithophysal unit of the Topopah Springs.

Review of Lithophysal Mapping Studies and Analysis

David Buesch (USGS) presented "Review of Lithophysal Mapping Studies and Analysis." He presented a study of lithophysae intended to provide a practical basis for understanding the variability of porosity, size, shape, and distribution of lithophysae for use in rock mass properties extrapolations and numerical modeling.

3) Rock Properties Determination - Laboratory and Field Testing

A summary of the current status of the rock properties laboratory and field-testing program was presented [see "Review of Laboratory Compression Testing of Cores" by Ron Price (Sandia), "Direct Shear Testing of Joints" by Steve Beason (USBR), "In-Situ Slot Testing" by Larry Costin (Sandia), "Time Dependent and Thermal Properties" by Ron Price (Sandia), "Micromechanical Modeling of Lithophysal Rock" by David Potyondy (Itasca), and "Adequacy of Existing Testing, Additional Planned Testing, and Summary" by Larry Costin (Sandia)].

Review of Laboratory Compression Testing of Cores

Ron Price (Sandia) presented "Review of Laboratory Compression Testing of Cores." He discussed the laboratory testing of large-size samples for the lower lithophysal rock unit. Tests were performed under a variety of conditions (temperature and saturation). He concluded that the mechanical properties of the rock in the lower lithophysal unit are sensitive to the presence of water.

Direct Shear Testing of Joints

Steve Beason (USBR) presented "Direct Shear Testing of Joints." The work includes direct shear testing of smooth cooling joints and rough vapor phase partings.

In-Situ Slot Testing

Larry Costin (Sandia) presented "In Situ Slot Testing." He described the three slot tests that have been completed. He pointed out that thermal loading could be significant with respect to potential near-drift rock failure. He also concluded that lithophysae have significant effects on mechanical properties of the lower Topopah Springs lithophysal rock unit.

Time Dependent and Thermal Properties

Ron Price (Sandia) presented "Time Dependent and Thermal Properties." He discussed the laboratory and field programs for determination of thermal conductivity. He also discussed the program for determining time-dependent mechanical behavior of Topopah Springs Tuff.

Micromechanical Modeling of Lithophysal Rock

David Potyondy (Itasca) presented "Micromechanical Modeling of Lithophysal Rock." His presentation addressed the modeling efforts completed thus far using the Particle Flow Code (PFC) to understand the mechanisms of deformation and failure of lithophysal rock. He also discussed the extension of these modeling results to determine the impact of lithophysal cavity

geometries (shape, size, and spatial distribution) on mechanical properties, including prediction of long-term rock behavior. The PFC model accounts for reduction of strength and modulus with increasing lithophysal volume fraction. It was concluded that the PFC model produced a reasonable representation of the failure mechanisms observed in laboratory experiments. Mr. Potyondy investigated the effect of lithophysal geometries, observed in actual panel maps, on mechanical properties. He also modeled the stress-dependent corrosion reaction in silicate rocks in the presence of water using a stress-corrosion model to degrade the particle-bond properties. This model could be calibrated by matching the results of static-fatigue tests being carried out.

Summary, Adequacy of completed/planned Testing, and Additional Planned Testing

Larry Costin (Sandia) presented "Summary of Adequacy of Existing Testing, and Additional Planned Testing." He summarized the status of test plan progress so far. Mr. Costin concluded that the characterization studies are essentially complete. Thermal-mechanical laboratory and in-situ tests are essentially complete; however, some analyses of test data and documentation are yet to be completed. Time-dependent deformation/failure tests are in progress.

4) Modeling and Analysis of Drift Degradation

General Overview of the Methodology and Approach to Drift Degradation Modeling

A summary of the current status of modeling and analysis of drift degradation was presented [see "General Overview of the Methodology and Approach to Drift Degradation Modeling" by Mark Board (BSC), "Drift Degradation from Seismic, Thermal, and long-term Effects in Non-Lithophysal Rocks and Lithophysal Rocks" by Ming Lin (BSC) and Branko Damjanac (Itasca), "Thermal Conductivity in the Ventilation Model" by John Case (BSC), "Ground Support Studies and Design Status" by Fei Duan (BSC), and "Summary of Work Effort, Expectation for use of the Program Information in Evaluating FEPs" by Mark Board (BSC)].

Drift Degradation from Seismic, Thermal, and Long-term Effects in Lithophysal and Non-lithophysal Rocks

Ming Lin (BSC) presented "Drift Degradation from Seismic, Thermal and Long-Term Effects in Non-Lithophysal Rocks." Mr. Lin discussed the study being conducted to produce a geologically-based estimate of the distribution of rockfall for non-lithophysal rocks as a function of geology, rock mechanics, thermal load, and ground motion; and estimated changes in drift profiles resulting from progressive deterioration of the emplacement drift. Rockfall has been defined in terms of block size distribution; total weight of rockfall per unit length of drift; and velocity, location, and geometry of blocks impacting a drip shield.

Branko Damjanac (Itasca) presented "Drift Degradation from Seismic, Thermal and Long-Term Effects in Lithophysal Rocks" and discussed the study being conducted to produce a geologically-based estimate of the distribution of rockfall for lithophysal rocks as a function of geology, rock mechanics, thermal load, and ground motion; and estimated changes in drift profiles resulting from progressive deterioration of the emplacement drift. Mr. Damjanac described a Universal Distinct Element Code (UDEC) model using Voronoi blocks. The model was calibrated using test results of lithophysal rock and used this model to simulate the response of drifts in lithophysal rock under different loading conditions, such as thermal, seismic, and long-term degradation.

Thermal Conductivity in the Ventilation Model

John Case (BSC) presented "Thermal Conductivity in the Ventilation Model" and discussed the logic in relating field geologic measurement of lithophysal porosity to analytical models of rock mass thermal conductivity for eventual use in an engineering calculation of ventilation efficiency.

Ground Support Studies and Design Status

Fei Duan (BSC) presented "Ground Support Studies and Design Status" and presented an overview of the ground support design status and the requirements for ground support. The design criteria for ground support include monitoring, inspection, and maintenance; and material acceptability and longevity. Additionally, the ground support would be designed with a service life of 75 years with an option to include a potential life extension of up to 300 years with appropriate maintenance and inspection program. Mr. Duan also pointed out that the maintenance plan and associated monitoring program are in development.

Summary of Work Effort, Expectation for Use of the Program Information in Evaluating Features, Events and Processes (FEPs)

Mark Board presented "Summary of Work Effort, Expectation for Use of the Program Information in Evaluating FEPs."

Closing out the meeting, Roger Keller presented a "Crosswalk to Other KTIs."

Major Observations of NRC and DOE Responses:

- NRC staff commented that DOE's strategy is a coherent response to RDTME's questions on rock properties and rock behavior which have been discussed for the last ten years.

- NRC staff observed that the preclosure drift stability calculations used a small fraction of the actual thermal load (70 to 90 percent of the heat is assumed to be removed through ventilation). Because of its importance, the staff will review the ventilation design and associated assumptions.

- NRC staff noted it was unclear to them what the technical bases were for DOE's confidence in its predictions that another intensely fractured zone (similar to the one encountered during ESF construction) will not be found in the repository. The technical bases and attendant uncertainties for the assumption should be documented. DOE agreed and noted that this is already planned to be addressed.

- NRC staff noted that the use of qualitative measurements (e.g., "looks geologic") to assess the representativeness of a synthetic fracture model to the field measurements is inadequate. Quantitative measures (e.g., in terms of dip orientation, trace length, fracture spacing, rock quality designation) would be needed.

- NRC staff recommended that, in addition to the calibration already done using unconfined compression test data and the proposed calibration using in-situ slot test results, DOE should include existing triaxial test data on small samples in the calibration of the PFC and UDEC Voronoi models.

- NRC staff recommended that the variability of rock modulus and strength in the drift stability assessment should be considered. DOE indicated that they will consider the variability of the appropriate parameters within each of the rock mass categories.

- NRC stated that the design-basis ground motions for preclosure should be 1,000-year and 10,000-year return period earthquakes, as agreed to in the Seismic Topical Report 2. DOE pointed out that the 2,000-year earthquake used for preclosure analysis was just a baseline analysis; however, appropriate preclosure design-basis ground motions will be used in the design of structures, systems, and components important to safety.

- Although DOE concluded that postclosure ground motion would cause relatively minor drift damage in the non-lithophysal rock due to rockfall, NRC staff believe this conclusion is not supported by the results presented by DOE. DOE concurred with NRC's observation and indicated that supporting aspects of the results on drift stability would be presented in the Drift Degradation Analysis and Model Report (AMR).

- In response to a discussion item, NRC staff agreed to make available to DOE its own independent drift degradation analysis just completed by the Center for Nuclear Waste Regulatory Analyses as soon as the staff review of the contractor report is completed.

- NRC pointed out that there is evidence that clay minerals occur in the repository horizon rocks and potential alteration of such clay minerals under the effects of temperature and moisture over long periods of time needs to be considered in the drift degradation analysis. DOE stated that clay minerals are rare in the repository horizon, and the conditions needed for their formation during the pre- or post-closure time frame are absent.

- NRC noted that DOE presented analyses that consider the combined effects of thermal and seismic loading of the drift stability of the middle nonlithophysal unit of the Topopah Springs. A similar analysis was not presented for lower lithophysal unit; however, it is included in the Drift Degradation AMR.

- NRC staff pointed out that drip shield placement and Preclosure Safety Assessment should be included in the list of requirements for ground support. DOE agreed.

- In response to NRC staff's observation that a monitoring and maintenance plan for the emplacement drift ground support system is needed, DOE indicated that this is under development.

- In response to NRC staff's questions, DOE confirmed that the results of drift degradation analyses will be used to reexamine the screening decisions for the rockfall and drift collapse FEPs.

- NRC staff encouraged DOE to integrate the results of the fracture and lithophysal studies discussed in this Technical Exchange into other Key Technical Issues that utilize such information (e.g. USFIC, TEF, ENFE, as well as RDTME and SDS).

- NRC staff pointed out the need to define the preclosure period and communicate to NRC all the assumptions related to design life for structures, systems, and components important to safety. DOE plans to do so.

Public Comments

- Mr. Steve Frishman (State of Nevada) stated that since the measured fractures represent the condition of least stability and the computer generated fractures provide more stable conditions for the repository drifts, it is not reasonable to use computer generated fractures to predict drift stability.

- Mr. Shettel (State of Nevada) complimented the Bureau of Reclamation on the geologic mapping performed. He suggested that the Lawrence Berkeley Laboratory should be made aware of the mapping information. He expressed a concern about the proposed ventilation, namely that a phase change could result in an undesirable precipitation of minerals. Finally, he questioned the use of the Particle Flow Code for validating other models. Mark Board responded that the code was not used to validate other models, but was used simply to understand the processes.

- Ms. Judy Treichel (Nevada Nuclear Waste Task Force) expressed an appreciation for the tough questions posed by NRC. A concern was also expressed that the Nuclear Waste Policy Act may not have been followed, leaving NRC with much catching up to do. Ms. Treichel expressed the hope that NRC would not be afraid to say the site "won't work", if that was the Commission's ultimate finding.

- Mr. Englebrecht V. Tiesenhausen (Clark County) stated that lithophysal rock units are highly heterogeneous. Because of differences in thermal conductivity, hot spots may be present. Mr. Tiesenhausen asked whether DOE staff has looked into this possibility and studied the potential effect.

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