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

February 6-8, 2001
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management 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) key technical issue (KTI) and sufficiency review and the U.S. Department of Energy (DOE) site recommendation decision. Consistent with NRC regulations on prelicensing consultations and a 1992 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. Resolution at the staff level does not preclude an issue being raised and considered during the licensing proceedings, nor does it prejudge what the NRC staff evaluation of that issue will be after its licensing review. Issue resolution at the staff level, during prelicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. The discussions recorded here reflect NRC's current understanding of aspects of repository design and thermal-mechanical effects 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 (e.g., Analysis and Model Reports (AMRs) and Process Model Reports (PMRs)). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

Issues are "closed" if the DOE approach and available information acceptably address staff questions such that no information beyond what is currently available will likely be required for regulatory decision making at the time of any initial license application. Issues are "closed-pending" if the NRC staff has confidence that the DOE proposed approach, together with the DOE agreement to provide the NRC with additional information (through specified testing, analysis, etc.) acceptably addresses the NRC's questions such that no information beyond that provided, or agreed to, will likely be required at time of initial license application. Issues are "open" if the NRC has identified questions regarding the DOE approach or information, and the DOE has not yet acceptably addressed the questions or agreed to provide the necessary additional information in a potential license application.

The objective of this meeting was to discuss and review the progress on resolving the RDTME KTI (see Attachment 1 for the description of the subissues). The quality assurance (QA) aspect of this KTI was determined to be outside the scope of the meeting and is being tracked in NRC's ongoing review of the DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 and 4 are "closed," and Subissue 2 and 3 are "closed-pending." Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. Information

pertaining to Subissue #3, Agreement 4 is provided as Attachment 2. The agenda and the attendance list are provided as Attachments 3 and 4, respectively. Copies of the presenters slides are provided as Attachment 5. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

In its opening comments, the NRC stated that it had received valid comments about the terms used to document the status of technical issues during the prelicensing stage, specifically about the use of the term "closed-pending." The NRC stated that it is possible to infer from the use of "closed-pending" that more progress has been made in closing an open issue than is actually the case. In a letter dated January 22, 2001, the Chairman of the NRC addressed this issue and copies of the letter were made available at the meeting. In his letter, the Chairman discussed the terms used and indicated that to mark the status of a technical issue during the prelicensing stage, the NRC used "closed," "closed-pending," and "open" as "bookkeeping terms." The NRC then discussed the terms and the goal of issue resolution (this discussion is similar to what is discussed in the Introduction and Objectives section above and is not repeated here).

The DOE stated that the intent of the meeting was to reach agreement on the current status and path forward for each of the RDTME subissues (see "Repository Design and Thermal-Mechanical Effects" presentation given by Kirk Lachman). In the RDTME Issue Resolution Status Report (IRSR), Revision 3, the NRC stated that RDTME Subissues #1 and 4 are "closed," Subissue #2 is "closed-pending," and Subissue #3 is "open." During this meeting, the DOE stated that its presentation would focus on the open items identified by the NRC in the IRSR and subsequent discussions. The DOE stated that it felt that the details provided during the current meeting would be the basis for NRC to continue to list Subissues #1 and 4 as "closed," and Subissues #2 and 3 as "closed-pending."

2) Technical Discussions - Subissue 1: Design Control Processes; Subissue 2: Seismic Design Methodology; Subissue 4: Repository Seals

A summary of the current status of resolution was presented (see "Subissue 1: Design Control Processes; Subissue 2: Seismic Design Methodology; Subissue 4: Repository Seals" presentation given by Dan McKenzie and Richard Quittmeyer).

Subissue 1: Design Control Processes

The DOE stated that it has developed a technical work control process consistent with the quality assurance program. The DOE stated that the NRC has identified this subissue as "closed" in the RDTME IRSR, Rev. 3 and considers that this subissue remains "closed." The NRC noted that most of its review to date in this area was in response to design control concerns related to the Exploratory Studies Facility. The NRC further stated that, although the design control process was acceptable, it would continue to monitor implementation of the design control process, especially in the pre-closure area, and would bring relevant issues to the DOE's attention as they arise. The DOE also clarified that the same requirements are

applicable for design and performance assessment. As a result of additional discussions, the NRC stated that Subissue #1 could continue to be listed as "closed."

Subissue 2: Seismic Design Methodology

The DOE discussed the seismic design methodology which is the subject of the second in a series of three topical reports. The DOE noted that the first two topical reports had been completed and that the NRC had no further questions related to them. The NRC stated that after receiving Topical Report 3, it would review all three topical reports in an integrated manner and may have questions related to the first two topical reports at that time. The NRC also asked whether the substantive technical content of Topical Report 3 could be provided prior to publication of the formal report which is currently scheduled for completion in 2002. The DOE stated that it would provide the preliminary seismic design input data sets used in site recommendation design analyses to the NRC by April 2001.

As a result of additional discussions, the NRC and DOE reached two agreements for Subissue #2 (see Attachment 1). With these two agreements, the NRC stated that Subissue #2 could be listed as "closed-pending."

Subissue 4: Repository Seals

The DOE stated that it does not take credit for the use of repository seals in the performance assessment. Based on this fact and that the NRC listed this subissue as "closed" in the RDTME IRSR, Rev. 3, the DOE stated that it considers this subissue "closed." The NRC noted that information pertaining to seal design, construction, and material selection was still required even though seals are not relied upon in meeting the performance objectives and proposed 10 CFR Part 63 does not include requirements specific to seals. The NRC also stated that any potential negative impacts of seal construction and seal materials must be evaluated by the DOE. The DOE stated that such an evaluation is part of its overall evaluation of repository performance.

Mr. Steve Frishman (State of Nevada) stated that this would be the first time the NRC would be basing its decision to list a subissue as "closed" based on proposed 10 CFR Part 63. He stated that either this issue should remain open with respect to 10 CFR Part 60, or if listed as "closed," it should be linked to proposed 10 CFR Part 63. The NRC stated that in its discussion of Subissue #4, closure is linked to proposed 10 CFR Part 63.

As a result of additional discussions, the NRC stated that Subissue #4, with respect to proposed 10 CFR Part 63, could continue to be listed as "closed."

3) Features, Events, and Processes Relevant to RDTME

The DOE summarized the total system performance assessment process, including the identification and screening of features, events, and processes (FEPs). The NRC questioned what was meant by the phrase "effect partially included" in the FEPs table. The DOE stated, that it took no credit for ground control systems in postclosure, and, even if a primary FEP were excluded, the associated secondary FEPs could still be included in the total system

performance assessment. The backup material on this presentation includes examples of included, excluded, and partially included FEPs.

The NRC questioned the DOE about screening out rockfall. The DOE stated that rockfall was screened out because the design of the waste package and the drip shield would take into account the design basis rock size. The NRC stated that it would address this issue again in the subsequent presentations, specifically in Subissue 3, Component 3, Acceptance Criterion 5.

4) Technical Discussions - Subissue #3, Thermal-Mechanical Effects on Underground Facility Design and Performance

Component 1, Thermal-Mechanical Effects on Design of Underground Facility

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 1, Thermal-Mechanical Effects on Design of Underground Facility" presentation given by Dan McKenzie, Barry Thom, Richard Quittmeyer, and Fei Duan). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information related to the various acceptance criteria (AC).

Acceptance Criterion 1 addresses the design assumptions, codes, and standards used for the design of subsurface facility structures, systems, and components important to safety. The DOE stated that design control is described in Procedure AP-3.13Q, which requires the design to be developed in accordance with system description documents. The NRC questioned whether the DOE would update the requirements to correspond to the most current version of the ASME Boiler and Pressure Vessel Code. The DOE stated that, for now, the design will be based on the 1995 ASME Boiler and Pressure Vessel Code. Furthermore, the DOE stated that they would generally "freeze" the selected codes and standards and not continuously revise the design to keep up with evolving version of codes and standards, consistent with industry and NRC practice for reactors, and spent nuclear fuel dry cask storage licenses.

The NRC asked how the applicability/appropriateness of various design codes and standards are determined, particularly for situations for which standards do not exist. The DOE stated that they use engineering judgement, industry and NRC practices and precedents to choose the appropriate design code and standard and document the basis for the decision in Appendix A of the appropriate system description document.

Acceptance Criterion 3 addresses the materials and material properties used for the subsurface facility design. The DOE stated that material standards are specified in the system description documents. The ultimate selection of committed materials is an iterative process involving the subsurface designers and performance assessment team. The NRC questioned the technical basis of precluding corrosion of rock bolts and maintaining relative humidity less than 40%. The DOE stated that their position regarding corrosion is based on previous waste package overpack studies and their position regarding relative humidity is based on Yucca Mountain meteorology data and ventilation calculations.

The NRC questioned why temperature dependent effects on engineered barrier system materials were not discussed. The DOE stated that this issue would be discussed in more detail in later presentations, specifically Subissue 3, Component 2, Acceptance Criterion 2.

Acceptance Criterion 4 addresses whether design analyses use appropriate load combinations for normal and Category 1 and 2 event sequence conditions. In its presentation, the DOE addressed three specific NRC concerns: (1) appropriateness of in-situ stress ratio, (2) incorporation of thermal load in ground support design, and (3) appropriateness of seismic design inputs for design analysis.

In its discussion of in-situ stress ratio (K_o), the DOE stated that both hydraulic fracturing data and Goodman Jack measurements indicate that K_o values of 0.3 and 1.0 are lower and upper bounds for the horizontal to vertical stress ratio, respectively, at the proposed repository host horizon.

In its discussion of thermal load in ground support design, the DOE stated that thermal loads for thermal-mechanical models are based on the heat output and ventilation rate from thermal management analyses and use them as input for the ground control analyses. The DOE further stated that the thermal load used is the upper bound. The NRC questioned how the upper bound was determined and how the DOE plans to maintain the temperature below the upper bound. The DOE stated that the project design goal for preclosure emplacement drift wall temperature is 96°C (below boiling point) and that modeling was performed using peak preclosure drift wall temperatures of approximately 125°C. The DOE indicated that it would use the design to control peak temperature (e.g., adjust the spacing of waste packages, change ventilation rate, etc.).

In its discussion of seismic design inputs, the DOE stated that the Seismic Design Inputs AMR will contain the inputs to be used for design. The NRC requested that the critical combinations of in-situ, thermal, and seismic stresses for the period of interest, together with their technical bases, and their impact on ground support system be provided.

Acceptance Criterion 5 addresses whether the design analyses use appropriate models and site-specific properties of the host rock, and consider spatial and temporal variation and uncertainties in such properties. In its presentation, the DOE addressed four specific NRC issues: (1) justify mechanical properties for continuum rock mass modeling, (2) justify mechanical properties for discontinuum rock mass modeling, (3) provide basis for mechanical degradation of rock support materials, and (4) justify thermal-mechanical modeling.

In its discussion of mechanical properties for continuum rock mass modeling, the DOE stated that the models are appropriate and adequately justified, and that NRC concerns on mechanical properties will be examined through sensitivity studies. The NRC asked why the 1997 Yucca Mountain Geotechnical Characterization Report concluded that additional information was required, but that the DOE now considers the information to be acceptable. The NRC asked for details regarding any additional work that was conducted since March 1997 and where the results were documented. The DOE stated that the information was available in various sources in the Technical Document Management System and it will provide the additional information in a future document.

The DOE discussed two reports expected to be completed in fiscal year 2002, Design Parameter Analysis and Rock Mass Classification Analysis. The NRC indicated that additional information was needed in these two documents, as well as a third report documenting sensitivity analyses in fiscal year 2003. The DOE stated it would provide these three reports.

In its discussion of mechanical properties for discontinuum rock mass modeling, the DOE stated that its discontinuum rock mass models are appropriate and adequately justified, and that NRC concerns on mechanical properties for blocks between fractures, fracture patterns, and fracture friction angle will be examined through sensitivity studies.

In its discussion, the DOE indicated that both continuum and discontinuum modeling were used to conduct ground control analysis for emplacement drifts for site recommendation. The NRC noted that performance of ground support systems were not modeled using discontinuum modeling and the results from discontinuum modeling may drive the support design.

The DOE discussed the seismic analysis conducted in its ground control for emplacement drifts for site recommendation. The NRC questioned the use of sinusoidal time history with single frequency and short duration because a sinusoidal signal may not be able to bound the site-specific ground motion time history. The DOE responded that its study indicated that effects of frequency and time history on rock bolts were analyzed and no effects were found; however, no documentation is available for review. The DOE stated their position that the ground control design was sufficiently robust, but would agree to additional discontinuum analysis to further enhance the understanding of ground support performance.

In its discussion of mechanical degradation of rock support materials, the DOE stated that it has adequately documented the basis for mechanical degradation of rock support materials.

Acceptance Criterion 6 addresses whether the design of ground support systems is based on appropriate design methodologies and interpretations of modeling results. The DOE stated that numerical approaches are the primary means of analyzing ground support design. The selection of ground support systems is compared against the empirical approach. The NRC asked what empirical data is being used for comparison with the numerical ground support calculations. The DOE responded that they used the empirical design methodology for conventional underground excavation to check the numerical results.

Acceptance Criterion 7 addresses whether subsurface ventilation systems are adequately analyzed. The DOE stated that it has extensively evaluated and checked the ventilation model since its development in 1995. To enhance confidence that the model is adequate, the DOE stated that model results are compared with results from another model that performs similar calculations. In addition, an ongoing 1/4-scale test at the Atlas Facility will provide data that can be used to gauge the accuracy of the model. The NRC raised questions regarding the discretization employed in the ANSYS ventilation model. The DOE responded that based on their study of using more discretized segments, their discretization is adequate.

The NRC questioned whether radial heat flow is adequately represented in the Atlas ventilation testing. The DOE responded that they are continuing to evaluate this issue. The DOE also emphasized that the primary objective of the ventilation test is presently limited to verifying the ANSYS ventilation model.

The NRC pointed out that the line load assumption used in the ANSYS ventilation model may not be applicable if the waste package spacing within the drift is significantly increased. The DOE responded that there would be some additional effects if the spacing were increased significantly. The spacings currently being considered do not appear to cause large temperature disparities, and that they may have to address this concern if, at a future time, it is determined that waste package spacing will in fact be increased. The DOE stated that one report would synthesize all the ventilation test results and would include comparison with numerical models.

Component 2 – Effects of Seismically Induced Rockfall in Engineered Barrier Performance

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 2, Effects of Seismically Induced Rockfall in Engineered Barrier Performance" presentation given by Dwayne Kicker and Scott Bennett). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information in the appropriate acceptance criteria.

Acceptance Criterion 1 addresses the evaluation and abstraction of design features and processes. In its presentation, the DOE addressed nine specific NRC issues: (1) basis of assumption regarding modeling of joint plane radius, (2) representativeness of joint mapping data, (3) basis for exclusion of small joint trace lengths, (4) treatment of thermal and long-term degradation of joint strength, (5) joint sampling bias, (6) temperature dependency of titanium material properties, (7) design basis rock size, (8) use of 10^{-4} ground motion values for postclosure seismic ground motion analysis, and (9) verification of key block analysis approach.

The NRC raised questions regarding the location of the model boundaries being located too close to the drift. The DOE responded that they will reconsider the location of the model boundaries. The DOE stated that it used subcritical crack propagation theory to simulate thermally-induced degradation of joint cohesion. The basis of this methodology is the assumption that joints are either not persistent (joint bridge) or with filling material. The NRC expressed concerns about the approach and a lack of field data to justify the simulation. Furthermore, the DRKBA program does not simulate joint bridges. Consequently, assuming that joint cohesion is a result of joint bridge is not a reasonable assumption. The DOE said it plans to perform additional analysis to verify the approach.

The NRC asked if observations in the field justify the joint filling assumed in the key block analyses. The DOE responded that such joint filling ("locked patches") is common in Yucca Mountain.

The DOE briefly discussed its positions on the status of fracture data adequacy for input to rockfall analysis. The DOE believes that sufficient fracture mapping data have been obtained and are representative of the potential repository area. The DOE further believes that it has resolved the NRC's concern about fracture sampling-bias errors (in the Fracture Geometry Analysis AMR). The NRC stated that these issues will be addressed in future interactions with the Structural Deformation and Seismicity KTI staff who are reviewing the DOE's technical bases.

The NRC questioned the exclusion of small trace length joints as being conservative in terms of block size. The DOE responded that not including small trace length will result in relatively larger size rock blocks and, therefore, it is conservative. The NRC pointed out that while it may be the case for Topopah Spring crystal-poor middle non-lithophysal unit, it may not be the case for Topopah Spring crystal-poor lower lithophysal unit. The DOE indicated that field observations in the lower lithophysal do not suggest the occurrence of large blocks. The DOE indicated that it will examine the effect of small trace length joints on block number and size.

The NRC commented that the DOE determination of shape and size of rockfall blocks using UNWEDGE program did not include the effect of variation of joint dip angle. The DOE stated that the approach used was based on field observations in which strike variation was more prominent than dip variation. The DOE stated that dip variation will be evaluated. The NRC questioned the representativeness of fracture data used to obtain potential rock block size. The DOE responded that the fracture data set for the site was one of the most extensive in the world. Specifically, the fracture data set for the lower lithophysal unit in the Repository Host Horizon was derived from approximately 1000 meters of continuous exposure in the enhanced characterization of the repository block and that it is considered sufficiently representative for the same lower lithophysal located in the emplacement drift area.

The NRC pointed out that the technical bases for the result that the drip shield can withstand a 10MT rock has yet to be provided. Various agreements were made at the CLST Technical Exchange to address this issue however.

The NRC questioned how seismic effects can be accounted for by friction angle. The DOE responded that the technical basis for the approach is documented in the Drift Degradation AMR. The NRC raised concerns regarding validity of the verification analyses presented by the DOE. The DOE stated that the seismic effects approach is adequate, based on the consistent prediction of blocks compared to an alternate numerical solution, and based on the comparison to natural analogues of seismic motion. The DOE stated further that it plans to perform more analyses to verify the approach.

The NRC questioned the frequency and duration of sinusoidal loading used in the verification analysis and the technical basis for the response measure used to compare the analysis cases. The DOE responded that the objective of the verification analyses to confirm the adequacy of the quasi-static approach was fulfilled by the approach used.

Acceptance Criterion 2 addresses the sufficiency of data. In its presentation, the DOE addressed three specific NRC issues: (1) temperature dependency of titanium material properties, (2) adequacy of drip shield stress analysis, and (3) adequacy of stress corrosion cracking analysis. The DOE concluded that the data collected to date, analysis performed, and planned work captured in existing Container Life and Source Term (CLST) agreements with the NRC support closure of this criterion. The NRC asked several clarifying questions regarding the boundary conditions for the finite element models used to assess the consequences of rockfall on the drip shield and waste package. The DOE indicated that they are modeling the drip shield as a free standing structure and include the potential interaction with the gantry rail in the analyses. The DOE also pointed out that they are accounting for the ground motion by including the effects of the invert floor moving vertically upward in their drip shield and waste package models.

Acceptance Criterion 3 addresses the data uncertainty. The DOE concluded that data collected to date, analyses performed, and planned work captured in existing CLST agreements with the NRC support "closed-pending" of this criterion as it pertains to the presently proposed engineered barrier materials.

Acceptance Criterion 4 addresses alternative conceptual models. The DOE stated that it considers this criterion to be "closed-pending" completion of additional rockfall verification and completion of additional waste package and drip shield analyses as agreed to during the CLST meeting. The NRC raised concerns on the applicability of the DRKBA code to determine rock block size and distribution under seismic and thermal conditions. The DOE stated that it believes DRKBA code gave reasonable results based on the verification activities described under Acceptance Criterion 1 and will conduct further verification studies to confirm the DRKBA results.

The NRC questioned how the DOE accounted for the multiple rock block scenario. The DOE responded that it may account for the multiple rock block scenario by using maximum available block size. The NRC stated that it will review the analysis when it becomes available. The DOE also stated that it will assess the effect of fall height associated with subsequent rock fall at the same location on waste package and drip shield performance.

Acceptance Criterion 5 addresses model abstraction. The DOE stated that because rockfall has been excluded from TSPA based on low consequence, this criterion is not applicable. However, the DOE stated that based on the information presented under AC #1, additional rockfall verification analyses are being considered.

Component 3 – Thermal Effects on Flow into Emplacement Drifts

A summary of the current status of resolution was presented (see "Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance – Component 3, Thermal Effects on Flow into Emplacement Drifts" presentation given by Bo Bodvarsson, Robert MacKinnon, Ernest Hardin, and Stephen Blair). The DOE identified the NRC information needs from Revision 3 of the RDTME IRSR and subsequent discussions. The DOE stated that the presentation would provide the basis for going to "closed-pending." The DOE then presented the information in various acceptance criteria (AC).

The DOE divided the Component 3 presentation into three parts with their associated AC: (1) Degradation of Engineered Barriers, (2) Quantity and Chemistry of Water Contacting Waste Packages and Waste Forms, and (3) Spatial and Temporal Distribution of Flow.

In the discussion of the degradation of engineered barriers, the DOE addressed two issues: (1) the adequacy of treatment of seismic and thermal loading in drift degradation analysis, and (2) assumption of thermal load initial conditions for thermal-hydrological effects on the engineered barrier environment.

The DOE stated that the effect of floor heave on engineered barrier system performance has been screened out because the predicted displacement is only about 10 millimeters. The NRC asked whether the DOE was counting on the drifts remaining stable for the entire 10,000 year

period. The DOE stated that its analysis results showed that there will be only 40 cubic meters of fallen rock in one kilometer length of the drift. The NRC asked what the effects of natural backfill on engineered barrier system component temperatures would be. The DOE stated that the thermal effects results would be similar to and generally bounded by the analysis which was done for the design option that included backfill.

The DOE stated that as a basis for closure of the fracture permeability issue, it was considering additional modeling to evaluate spatial heterogeneity effects, which would include major faults and other permeable features. The DOE has identified spatial heterogeneity of fracture characteristics as a potentially important factor for seepage during the thermal period, as well as for post-thermal (ambient) seepage. The DOE has a three-dimensional study underway which incorporates fracture sets used in the Drift Degradation Analysis. This study will provide a basis for resolution by estimating the fracture permeability over time resulting from thermal-mechanical effects. Results will be documented in the Coupled Thermal-Hydrologic-Mechanical Effects on Permeability AMR.

In the discussion of the quantity and chemistry of water contacting waste packages and waste forms, the DOE addressed six NRC issues: (1) evaluation of changes in drift geometry on water chemistry and quantity, (2) technical basis for parameters used to assess thermal-mechanical effects on hydrological properties, (3) technical basis for temperature distributions used in ventilation design, (4) alternative conceptual models to assess effects of changes in drift geometry, (5) alternative conceptual models to assess effects of changes in rock mass hydrological properties, and (6) alternative conceptual models to assess effects of changes in ventilation on water chemistry and quantity.

The DOE stated that thermal-hydrologic-mechanical effects on fracture permeabilities will vary for horizontal and vertical fractures that are in close proximity to drift openings. The NRC asked if water from the pillar will be diverted to the drifts. The DOE responded that its evaluation indicates that water diversion from pillar to drift is unlikely.

The NRC commented that the drift scale models are not adequate to capture thermal-mechanical effects on flow (a repository scale is required). The DOE described current models for evaluating the effects of changes in fracture properties, on flow fields in the host rock, and the potential for drift seepage. These models indicated that changes in fracture permeability of up to two orders of magnitude (comparable to existing variability) would not significantly change the flow fields or the potential for lateral diversion. Also, the vertical permeability in the pillars will likely remain more than sufficient for vertical drainage, given the magnitude of permeability changes which are expected to occur.

The NRC questioned whether drift collapse has been considered in drift seepage and accounted for in the TSPA code. The DOE stated that based on results from the Drift Degradation Analysis, the volume of rock expected to fall into a drift is small and has no significant impact on the seepage into the drift.

The DOE presented a basis for resolution of fracture permeability that includes a Distinct Element Analysis which: incorporates discrete fractures, provides stress redistribution due to local shearing along fractures, includes shear effects on permeability, and uses the cubic law to relate fracture deformation to permeability change.

The NRC asked why the model was set up to examine changes around the drift but not in the pillar. The DOE stated that the model will be modified in the future to include regions of the pillar that may affect seepage into the drift. The NRC asked for more information pertaining to the choice of fracture pattern. The DOE stated that the fracture pattern was selected to be consistent with hydrologic flow models.

The NRC questioned the primary sources of fracture data used in the three-dimensional discontinuum model. The DOE responded that the orientation data were taken from the Fracture Geometry Analysis AMR and the spacing data were taken from the Calibrated Rock Properties AMR. The NRC asked if the sensitivity analysis will include permeability changes in the pillar. The DOE stated it would.

The NRC asked how flux would be affected by changes in fracture aperture in the pillar. The DOE stated that experimental data does not indicate that changes in permeability in the pillars could lead to lateral diversion. The NRC noted that thermal loads are not accounted for in the pillars. The DOE acknowledged that repository thermal loading is not accounted for in the data. The NRC asked how major faults are being considered. The DOE stated that sensitivity analyses addressing this issue are planned and will consist of thermal hydrology modeling with spatially heterogeneous fractured properties. The NRC questioned how the DOE could consider its drift seepage analysis to be conservative though complete collapse of drifts was not accounted for in the analysis. The DOE stated that complete collapse is highly unlikely.

RDTME Subissue 3, Overall Status

As a result of additional discussions, the NRC and DOE reached 21 agreements for Subissue #3 (see Attachment 1). With these 21 agreements, the NRC stated that Subissue #3 could be listed as “closed-pending.”

5) Public Comments

Ms. Judy Treichel (Nevada Nuclear Waste Task Force) commented that (1) proposed 10 CFR Part 63 should not be used at this point since it is not final and that, 10 CFR Part 60 would be more appropriate, (2) the NRC should understand in more detail the DOE reliance on ventilation and ground support for the first 300 years, and (3) the NRC should not list subissues as “closed-pending” if the DOE states that it is still considering what course of action to take. Regarding the first issue, the NRC stated that the Commission directed that staff use a risk-informed, performance-based approach for Yucca Mountain. Proposed 10 CFR Part 63 was developed with this in mind and, for this reason, the NRC uses it as a reference in meetings with the DOE. When the final rule is published, the NRC will revisit each of the key technical issues to determine if additional information is needed from the DOE and whether the current status of the issue is appropriate. The NRC acknowledged the validity of Ms. Treichel’s second comment. Regarding her third comment, the NRC stated that it had reviewed past agreements and believed it was using the word “consider” appropriately in its agreements with the DOE. The NRC requested that Ms. Treichel identify specific agreements with which she takes issue and the NRC would discuss them with her.

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