Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Range of Thermal Operating Temperatures

September 18-19, 2001
Las Vegas, Nevada; Rockville, Maryland; and San Antonio, Texas

Introduction and Objectives

This Technical Exchange and Management Meeting on Range of Thermal Operating Temperatures 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 potential U.S. Department of Energy (DOE) site recommendation. This meeting was conducted by a three-way video-conference between the NRC (Rockville, Maryland), DOE (Las Vegas, Nevada), and the Center for Nuclear Waste Regulatory Analyses (CNWRA; contractor to the NRC, San Antonio, Texas).

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 potential 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 DOE's analyses of the range of thermal operating modes. 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., Supplemental Science and Performance Analyses). Pertinent additional information (e.g., changes in design parameters) could raise new questions or comments regarding a previously resolved issue.

NRC discussed the issue resolution definitions in the beginning of the meeting. Specifically, NRC stated that 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.

This is the second of two meetings on DOE's Supplemental Science and Performance Analyses report (SSPA). During the first meeting, held on August 2, 2001, in Rockville, Maryland, DOE (1) summarized the SSPA; (2) discussed potential changes in approaches and results from the DOE's Yucca Mountain Science and Engineering Report (YMS&ER); and (3)

Enclosure

discussed differences between higher-temperature and lower-temperature operating modes based on process models. This meeting focused on the NRC staff's questions pertaining to DOE's SSPA.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC stated that all the KTI Subissues remain closed or closed-pending. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The NRC comments, and the DOE responses which reflect discussions in the meeting, are included as Attachment 2. This Attachment is based upon the "Response to NRC Comments" presentation. A modification to an existing NRC/DOE agreement is provided as Attachment 3. The agenda and the attendance lists are provided as Attachments 4 and 5, respectively. Copies of the presentations are provided as Attachment 6. A copy of written public comments submitted are provided as Attachment 7. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

NRC opened the meeting with a general discussion of issue resolution goals and the objectives for the meeting. NRC described the opportunities for public involvement in the meeting and stated that staff would be available to discuss general comments or questions with members of the public during the breaks and after the meeting by calling the relevant staff member.

DOE provided an opening statement on the repository design described in the DOE's YMS&ER and the range of thermal operating modes described in the SSPA. DOE stated that the purpose of the meeting is to discuss the aspects of the models used in the YMS&ER and SSPA and Key Technical Issues potentially impacted by lower temperature operating modes. DOE provided their approach to potential future work. DOE noted various constraining factors that may impact any work which might be discussed as either routinely planned or that which may be in response to specific NRC and/or mutual concerns. DOE indicated that they have directed their contractor to develop a plan to support further development of the design and analysis for the lower temperature operating mode. DOE reiterated that all testing and analytical work performed to support any operating mode documented in a license application will comply with the NRC approved quality assurance program. DOE indicated that should the site be recommended, approved, and plans implemented, they will continue to evaluate the impact of the lower temperature operating mode upon the existing KTIs. DOE expressed that they did not consider detailed "KTI Agreement Items" on the SSPA's topics to be needed, by virtue of the SSPA's nature.

2) DOE Overview Presentation

DOE provided an overview of its SSPA (see "Summary of the FY01 Supplemental Science and Performance Analyses" presentation given by Robert Howard, in Attachment 5). DOE stated that the document provided three general types of information. Unquantified uncertainties were analyzed. Updates in scientific information were incorporated in the SSPA. Finally, analyses of thermal operating modes were presented. The information contained in the SSPA was

intended to provide insights on the effects of uncertainty and both conservatisms and optimisms in Analysis and Model Reports (AMRs), Process Model Reports (PMRs), and the Total System Performance Assessment Site Recommendation (TSPA-SR). DOE indicated that the information in the SSPA supplements previous information and does not replace the previous, quality-related documentation. The DOE indicated that if any supplemental information is deemed to be appropriate for incorporation in a potential license application, the information will be updated and included in the AMR, PMR or other quality-related license application support documentation. The contents of the two volumes of the SSPA were outlined, and the information transfer relationship between the two volumes was discussed. Developments beyond those in the TSPA-SR in each of the major areas (unsaturated flow, seepage, chemical environment of the engineered barrier system, waste package, waste form mobilization, flow and transport in the engineered barrier system, unsaturated transport, saturated zone transport, biosphere, and disruptive events) that are in the SSPA were presented. These developments and analyses are addressed in volume 1 of the SSPA. The types of analyses contained in Volume 2 of the SSPA were also discussed. Sensitivity studies to examine individual components and supplemental TSPA analyses in Volume 2 were addressed.

3) Discussion of NRC Comments

The discussion of the NRC comments (see "Response to NRC Comments" included in Attachment 5) was subdivided into four areas and was the document used during the meeting to discuss the NRC concerns. Attachment 2 (Final DOE Responses to the NRC Comments) contains the NRC's comments in the left column and the DOE's response to the comment in the right column modified to reflect the discussions during the meeting, as appropriate. Each NRC comment in an area of discussion was addressed.

The NRC comments and associated DOE responses on waste package and waste form were discussed first. The next area of discussion was on the unsaturated and saturated zones. NRC comments and the initial DOE responses to the NRC concerns on the engineered barrier system were then addressed. Finally NRC comments on integration, repository design, geology, total system performance assessment, biosphere, and disruptive events were discussed. In the final table (Attachment 2) DOE provided satisfactory responses to these comments and/or identified ongoing or planned work that will provide the required technical basis for parameters called into question.

Waste Package and Waste Form

NRC had several questions regarding the waste package and waste form. The questions raised and the DOE responses, which reflect the results of the ensuing discussions, are tabulated in Attachment 2. In addition, previous KTI issue resolution agreements that were determined to be relevant to each response are also identified and documented in the attachment.

Comments and questions relevant to the waste package and the waste form are numbers 6-12, 33, 50-52, 100, 112-115, 118-126, and 128. The initial DOE written response to questions 6-10, 12, 33, 50, 51, 112-115, 118, 121, 124, 125, and 128 were determined to be acceptable and no additional explanation from the DOE was required. NRC presented an observation for DOE's consideration that the data to support the DOE's response to Comment 7 was very limited. DOE acknowledged NRC's observation. NRC stated that the current data suggests a

non-linear response which would result in thermal aging effects at much lower temperatures than currently predicted by the linear extrapolation of the data. Question 11 addressed the apparent change in the drip shield failure time reported in the TSPA-SR compared to that reported in the SSPA. NRC commented that they had specific concerns about the treatment of the experimental data to determine the activation energy for the general corrosion temperature dependence. NRC also expressed concern that the statistical considerations for making a determination of a data 'outlier' is only valid if the data represents one population (i.e, there are no chemical effects). DOE responded that the differences are, in part, the result of the sampling during realizations and a difference in the treatment of the uncertainty for the titanium corrosion rates. Question 52 was related to question 6 and was focused on the method used to determine the activation energy for the alloy 22 corrosion rate. DOE responded that tests are ongoing to determine the corrosion rate and its dependence on temperature. DOE modified their response to include relevant CLST agreements consistent with question 6. The multiplication factor used in the dissolution rate for HLW glass was addressed in question 100. The NRC stated that methodology used by the DOE is not consistent with standard practices. DOE acknowledged the need to develop the technical basis for changes in the glass dissolution rates and reiterated that the purpose of the SSPA was to gain insight, consequently not all the related analyses were based on fully qualified data or methods. The use of the slip dissolution model (GE PLEDGE) to predict stress corrosion crack propagation was addressed in question 119. The DOE response indicated NRC acceptance of this approach, however NRC stressed that a peer-reviewed publication does not indicate Agency acceptance. It was concluded that the model used for stress corrosion cracking of the waste package and drip shield materials would need to be validated for the materials in the environment relevant to the repository. Question 120 addressed the triangular distribution used to model the residual stress uncertainty. NRC requested the DOE to provide the documentation to support the uncertainty distribution. The NRC staff questioned the reference cited in response to comment 122 and stated that fluoride is known to increase the corrosion rate of titanium alloys. NRC staff asked about the relevance of natural analogues obtained from reducing environments in question 123. DOE responded that additional natural analogue data is being obtained. NRC asked about the spatial heterogeneity of in-package chemistry in Question 126. It was agreed that this issue was covered by previous CLST, ENFE, and TSPAI agreements.

In the final table (Attachment 2) DOE provided satisfactory responses to the waste package and waste form comments and/or identified ongoing or planned work that will provide the required technical basis for parameters called into question.

Unsaturated and Saturated Zone

NRC comments and questions falling under the unsaturated and saturated zone category are numbers 13-18, 22-32, 37-46, 48, 49, 56, 63, 69-99, 101-108, 110, and 111. NRC staff questioned the initial DOE response to numbers 13, 15, 18, 22-24, 27, 43, 45, 56, 69, 71, 73, 75, 80, 84, 86, 87, 91, 92, 95, 96, 98, 99, 102, 105, 109, 110, and 111. The questions raised and the DOE responses, which reflect the results of the ensuing discussions, are tabulated in Attachment 2. In addition, previous KTI issue resolution agreements that were determined to be relevant to each response are also identified and documented in the attachment.

NRC questioned DOE's original response to comments 13 and 95, that dripping from rockbolts is due to condensation. DOE stated that existing preliminary chemical analyses support the conclusion that the observed water in the sealed portion of the cross-drift is a result of condensation, not seepage. Additional field evidence, such as geochemical data, was

requested from DOE to support their assertion. DOE stated that future analyses, if carried forward for a potential license application, will include field evidence for the modeling results. Further, the NRC staff has become aware, from sources outside of this meeting, of a major change proposed by DOE in unsaturated zone testing in the Enhanced Characterization of the Repository Block (ECRB) (e.g. shorten the sealed portion of the cross-drift by over 700 meters). The NRC has concerns that this change may be premature with regard to collecting the information needed to resolve questions about sources and magnitudes of drift seepage and condensation dripping. An Appendix 7 meeting is tentatively scheduled for early October to discuss with DOE their criteria for shutting down a significant portion of ECRB testing, and the data collected to support such a decision. NRC questioned DOE's initial responses to comments 24, 69, and 70, and requested that field evidence be provided if lateral flow through the Ptn layer is carried forward to a potential license application, and that the potential heterogeneity of the Ptn layer be tied to existing agreement TSPAI.3.23. NRC questioned DOE's original responses to comments 71, 91, and 92, related to the interpretations of the Cl data and of their use in inferring homogeneity of the transport mechanisms. DOE stated that there was insufficient data to evaluate small-scale heterogeneity in Cl concentrations, however, the average Cl concentration is in agreement with the spatially averaged results inherent in the site-scale unsaturated zone model.

The DOE response to comment 84 stated that the fracture porosities assigned in the different thermal-hydrologic-chemical models was the main reason for the differences. The NRC commented that it would be very important for the DOE to examine whether the porosities being assigned were representative of the bulk host rock. DOE stated that porosities were obtained by several different methods and that all results support the higher values currently used. DOE also stated that some of these methods are not influenced by the zone of disturbance in the vicinity of excavations. The NRC questioned DOE's initial response to comment 92. NRC was concerned that inability of the model to predict the very high chloride concentration in the Ptn and above indicated that the model may not be appropriately calibrated. DOE indicated that other boreholes had not shown higher chloride, and provided a reference. NRC commented that model predictions versus measured data for all pertinent borehole should be shown to allow an independent conclusion that the model can appropriately represent the field data. In the final table (Attachment 2) DOE provided satisfactory responses to the unsaturated and saturated zone comments and/or identified ongoing or planned work that will provide the required technical basis for parameters called into question.

Engineered Barrier System

All NRC comments and questions pertaining to the engineered barrier system addressed by the initial DOE responses were discussed. The comments and questions related to the engineered barrier system are 1-3, 5, 16, 17, 25, 28, 34-36, 38, 47, 50, 59, 61, 62, 66-68, 74, 106, 107, 109, 116, 117, 127, and 129.

In response to the NRC comment that none of the uncertainty and/or sensitivity analyses performed in the SSPA include the effects of drift collapse, DOE pointed out that they are continuing to do uncertainty analyses and examining an alternative model to improve the basis for screening rockfall from performance assessment abstractions per KTI agreements RDTME 3.15, 3.16, 3.17, and 3.19 (see comment 3 in Attachment 2). NRC reiterated their concern to the DOE staff, however, that the present approach used to predict the occurrence of drift collapse and rockfall within the emplacement drifts has yet to be verified or validated. Moreover, the fact that the results of the DRKBA computer program used by DOE to assess the

stability of the drifts under repository conditions were shown to be insensitive to changes in rock temperature may be indicative of deficiencies in the proposed DOE methodology.

Several engineered barrier system comments and questions were related to DOE's characterization of the quantity and chemistry of water coming into contact with the various engineered barrier system components. In summary, NRC has concerns regarding DOE's accounting of water after it enters the emplacement drifts by way of seepage (see numbers 5, 16, 25, 36, 38, 61,62, 66-68, 74, 106, 107, 116, 127, and 129). In the final table (Attachment 2) DOE provided satisfactory responses to the engineered barrier system comments and/or identified ongoing or planned work that will provide the required technical basis for parameters called into question.

Integration, Repository Design, Geology, Disruptive Events, and Biosphere
Other topical areas addressed during the Range of Thermal Operating Modes technical exchange included Repository Design, Geology, Disruptive Events, Biosphere, and the subsequent integration and interactions between the various disciplines accounted for in the Total System Performance Assessment (see comment 2, 4, 19-21, 53-58, 60, 64, and 65).

NRC comment 4 pointed out that the limiting temperature exposure for instruments, monitoring equipment, and remote access equipment is 50 °C (120 °F), but the emplacement drift temperatures, even for the LTOM, are well above this limit. DOE responded that the emplacement drift exhaust air temperature peaks at 60 °C (140 °F) and, as a result, increased airflow will be required in the drift to lower the temperature below the 50 °C (120 °F) threshold before the aforementioned performance confirmation equipment will be taken into the drift. Because the issues pertaining to performance confirmation are varied and diverse and are only conceptually planned, particularly with respect to the types of monitoring equipment and their subsequent placement and use, it was decided that further discussion regarding this comment was beyond the scope of the Range of Thermal Operating Modes technical exchange and should be deferred to a future meeting specifically addressing performance confirmation topics.

DOE and NRC staff discussed the comments (numbers 21 and 64 in Attachment 2) related to the DOE screening argument for criticality. The NRC indicated that DOE had made several unsubstantiated assumptions in their qualitative screening argument for criticality. These assumptions include that the waste package failures due to improper heat treatment would only result in cracks in the waste package and that no water could enter the waste package without failure of the drip shield. DOE believes that, for the purposes as stated in the SSPA, the qualitative argument for the criticality screening was adequate. This screening argument was explained in additional detail in DOE's initial response to the NRC. Subsequently, DOE modified the response in Attachment 2 to reflect the already planned revision of the quantitative screening argument for criticality. This screening argument includes using updated information on the potential for early waste package failure, provides an appropriate quantitative screening argument for criticality, and performs the "what-if" criticality evaluation using the Disposal Criticality Analysis Methodology Topical Report approach.

In the final table (Attachment 2) DOE provided satisfactory responses to the integration, repository design, geology, disruptive events, and biosphere comments and/or identified ongoing or planned work that will provide the required technical basis for parameters called into question.

4) Discussion of Overall Path Forward

The actions that described the DOE responses to the NRC comments have been arranged into the following four categories: (1) specific issue resolution agreements; (2) general issue resolution agreements; (3) conditional on the future adoption of cool repository design or on the future adoption of the approach used in the SSPA; and (4) response to a clarifying question. These categories are described next.

Some NRC comments (Attachment 2) address new analyses included in the SSPA that are relevant to the basecase repository design described in the TSPA-SR and YMS&ER. In this category are comments relative to early waste package failure that have not been previously addressed by the DOE. Comments 21 and 64 were modified indicating the updated technical basis for the screening of criticality from post-closure performance. The modified agreement table (Attachment 3) contains the changes to CLST.5.03 and includes where the updated technical basis is to be contained.

Many of the NRC comments (Attachment 2) discuss aspects of information and analyses that are already subject to existing KTI agreements. Where an existing agreement exists that is relevant to the NRC comment, it is noted in the DOE's response to the NRC comment. The following comments (3, 5, 8, 9, 10, 12, 13, 15, 16, 18, 21, 24, 27, 36, 37, 41, 42, 45, 46, 50, 56, 64, 69, 75, 78, 81, 82, 83, 93, 95, 96, 97, 98, 102, 103, 104, 106, 109, 110, 111, 113, 116, 118, 119, 120, 122, 123, 124, and 126) need to be addressed in the materials that are required by the noted existing agreements. A general agreement has been written in Attachment 1 to ensure that each of these comments are addressed in the identified KTI agreement.

Many of the NRC comments (Attachment 2) discuss aspects of information and analyses that would be needed if a lower temperature operating mode was used for a potential license application or address the approach that DOE used in the SSPA. If the DOE does adopt a lower temperature operating mode or the approach used in the SSPA is used for a potential license application, then the NRC will meet again with the DOE to discuss what additional information may be needed by the NRC for a high quality license application. The following comments would need to be addressed if the DOE does adopt a lower temperature operating mode or the approach used in the SSPA (1, 2, 6, 7, 11, 14, 17, 19 , 20, 23, 25, 26, 28, 29, 30, 32, 33, 34, 35, 38, 39, 43, 47, 52, 61, 62, 63, 66, 67, 85, 87, 94, 100, 117, 121, 128, and 129).

Many of the NRC comments (Attachment 2) requested clarifying information on work described in the SSPA. The DOE responses provided the necessary information to clarify the topic. The responses were not tied to any existing KTI agreement. The following comments reflect this category (4, 22, 31, 40 ,44, 48, 49, 51, 53, 54, 55, 57, 58, 59, 60, 65, 68, 70, 71, 72, 73, 74, 76, 77, 79, 80, 84, 86, 88, 89, 90, 91, 92, 99, 101, 105, 107, 108, 112, 114, 115, 125, and 127).

5) Public Comments

Frank Perna (local citizen) stated that the plan for the meeting was flawed because not all of the materials were provided to the participants. The meeting was both a video-conference and had a tele-conference bridge line available for people to call into the meeting. This meant that those people calling in did not have the materials prior to the meeting. He expressed concern on whether the impacts of terrorism, given the recent terrorist attack in New York and at the

Pentagon, have been adequately addressed for proposed activities at Yucca Mountain (e.g., cooling ponds and dry cask storage). He also provided examples of why he believes the current DOE Site Recommendation hearing process is problematic.

Tom McGowan (local citizen) made oral comments and submitted written comments (Attachment 6). His oral comments questioned the logistics of the meeting. He stated that the draft agenda provided to him had the wrong street and address, the final agenda did not contain a street address and a map of the location, the agenda did not indicate the need for a visitor's pass. He also questioned why the agenda was not mailed in advance as he had previously requested. He asked where was a glossary of terms used in the meeting and why the meeting was not recorded. The main focus of his oral comments are contained in his written comments (Attachment 6).

Judy Treichel (Nevada Nuclear Waste Task Force) stated that the larger footprint of the repository for a lower temperature operating mode meant that there was a greater possibility of igneous activity. She urged that the NRC require that the DOE meet after each appropriation cycle and explain the impacts of the DOE budget on the DOE's ability to obtain the information required by the NRC in the existing KTI agreements.

Carl DiBella (staff from U.S. Nuclear Waste Technical Review Board) commented that for those participating via a phone line only, it was difficult to hear what was being said. He stated that DOE has not produced a convincing study that the footprint of the repository needs to be changed to operate in a lower temperature mode. Finally, he stated that the title of the meeting was misleading, in that both DOE and NRC seemed to be only discussing the NRC's review of the SSPA, rather than focusing on the range of operating temperatures.

Don Shettel (State of Nevada consultant) questioned whether the DOE has bounded the range of water compositions that could contact the engineered barrier system components. He suggested that mixing on the surfaces of the materials of waters from different sources, and the presence of dust with more deleterious components than the infiltrating water, could cause compositions to be different than the two compositions that the DOE is using. He also indicated that the expansion area required for a lower temperature design is inadequately characterized.

Steve Frishman (State of Nevada) questioned the interpretation of the carbon-14 results presented in the response by DOE to the NRC comment 72. He suggested that there are two alternative interpretations of the carbon-14 data. He asked whether DOE has really evaluated the different alternative model and their implications.

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