

Summary Highlights of NRC/DOE Technical Exchange and Management Meeting on Structural Deformation and Seismicity

October 11-12, 2000
Las Vegas, Nevada

Introduction and Objectives

This Technical Exchange and Management Meeting on Structural Deformation and Seismicity (SDS) 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 preclicensing consultations and a 1992 agreement with DOE, staff-level resolution can be achieved during preclicensing 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 preclicensing, is achieved when the staff has no further questions or comments at a point in time regarding how the DOE is addressing an issue. Pertinent additional information 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 is to discuss and review the progress on resolving the SDS KTI (see Attachment 1 for list of 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 DOE's QA program.

Summary of Meeting

At the close of the Technical Exchange and Management Meeting, the NRC staff stated that Subissues 1 through 3 were closed-pending and Subissue 4 was closed. Specific NRC/DOE agreements made at the meeting are provided as Attachment 1. The agenda and the attendance list are provided as Attachments 2 and 3, respectively. Copies of the presenters' slides are provided as Attachment 4. Highlights from the Technical Exchange and Management Meeting are listed below.

Highlights

1) Opening Comments

DOE stated that the intent of the meeting is to reach agreement on the current status and path forward for each of the SDS subissues (see "Overview - Structural Deformation and Seismicity: Key Technical Issue" presentation given by Tim Sullivan). During the April 25-26, 2000, KTI Technical Exchange, the NRC listed Subissues 1 and 2 as "closed-pending" and Subissues 3 and 4 as "open." During this meeting, DOE stated that its presentation would focus on confirmatory and additional information, data, and analyses identified by the NRC during the April 2000 Technical Exchange and subsequent discussions. DOE stated that it felt that the details provided during the meeting would be the basis for NRC to list Subissues 1, 2, and 4 as closed-pending and Subissue 3 as "closed."

2) Discussion of SDS Subissue in the Total System Performance Assessment - Site Recommendation (TSPA-SR)

DOE presented an overview of the TSPA-SR process (see "Structural Deformation and Seismicity Subissues in the Total System Performance Assessment - Site Recommendation" presentation given by Peter Swift). DOE stated that the TSPA-SR process begins with the identification of features, events, and processes (FEPs). Each of the FEPs is then evaluated outside of TSPA by the appropriate subject matter experts. The evaluation of the individual FEPs are documented in the analysis and model reports (AMRs) and those that are not screened out are included in the TSPA-SR models. DOE stated that it is currently strengthening and clarifying the technical bases for excluding FEPs and will update all the FEPs AMRs by January 2001.

DOE then discussed the FEPs related to the SDS subissues. DOE stated that the TSPA-SR would not contain a separate scenario for new faulting or new fault displacement on existing faults, but would consider the effects of existing faults on unsaturated zone and saturated zone flow for the nominal (base case) scenario. DOE stated, with regard to seismicity, that the evaluation of cladding failure (commercial spent nuclear fuel cladding fragility only), due to seismic ground motion, is included in the nominal scenario. DOE stated that it is not taking performance credit for DOE spent nuclear fuel cladding. DOE stated that the only explicit effect of seismicity included in the TSPA-SR model is the potential failure of spent nuclear fuel cladding. A justification was given by DOE for the method utilized to abstract cladding failure. While it was acknowledged by DOE that the abstraction could be done similar to the representation of igneous effects on the repository, DOE presented performance assessment results to suggest that performance of the repository is not very sensitive to cladding performance. NRC expressed concerns that the calculated insensitivity of repository performance to cladding may change as other parts of the system model change. DOE responded that they have process controls in place to evaluate the impact of changes to the system model or supporting data.

DOE stated, with regard to the fracture framework, that the effects of existing fractures on unsaturated zone and saturated zone flow models are included in the nominal scenario. DOE stated that tectonic models were considered in the probabilistic volcanic hazards analysis (PVHA) and probabilistic seismic hazards analysis (PSHA) by experts in the respective expert elicitations. DOE further stated that the tectonic framework enters the TSPA indirectly through the geologic model.

The NRC requested clarification regarding the technical basis for screening FEPs from further consideration on low probability versus insignificant consequence to dose. DOE stated that this issue would be clarified in the update to the Features, Events, and Processes: Disruptive Events (ANL-WIS-MD-000005), ICN1 AMR (FEPs AMR).

The NRC then discussed the scope of the four SDS subissues and the relationship to other key technical issues (KTIs). The NRC stated that questions involving the use of fracture data in specific process models is beyond the scope of this technical exchange and should be deferred to other KTI technical exchanges as appropriate.

3) Technical Discussions - Subissue #1, Faulting

A summary of the current status of resolution was presented (see “Subissue #1: Structural Deformation and Seismicity - Faulting” presentation given by Kathy Gaither). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS Issue Resolution Status Report (IRSR), the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criterion.

To address faulting parameters for low probabilities derived from the PSHA, the DOE proposed using median rather than mean values. The rationale given was that the median better reflected the central tendencies of the faulting data in the 10^{-6} to 10^{-8} range. In this range, the mean values are skewed beyond the 85th percentile. Regarding the acceptance criteria, the NRC raised questions regarding the use of median fault displacement as the appropriate measure for screening. The NRC stated that using the mean statistic is more appropriate, and consistent with its proposed 10 CFR Part 63 regulations. DOE stated that it is using the mean hazard for the pre-closure period and would use the median for the post-closure period. DOE stated that the approach of using median is consistent with NRC practice, specifically described in Regulatory Guide 1.165, “Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground Motion.” As a result of further discussion, the NRC identified and discussed five possible approaches for DOE to consider to address its concerns: (1) use mean fault displacement for probability based screening; (2) use a consequence analysis as a screening tool; (3) use maximum fault displacement as a deterministic screening criterion; (4) reconvene the expert elicitation panel to reconsider uncertainty in fault displacement of low probabilities; or (5) supply additional technical justification for the use of the median. Following additional discussions, the NRC stated that in a risk-informed regulatory environment, DOE could choose to use any statistical measure, but the DOE must provide technical basis to support their approach.

The NRC raised questions regarding the rationale for faults/faulting that are included and excluded from consideration in performance assessments. DOE stated that the basis for inclusion or exclusion of fault displacement is established in the update to the FEPs AMR. The NRC also had questions regarding the setback distance. DOE stated that the current setback distance of 60 meters from block-bounding faults is based on engineering judgment, and is measured from the trace of the fault. In addition, DOE stated that the setback was measured from the center of the fault and not from the surrounding deformed (shear) zone along the fault.

(In a subsequent follow-up question, DOE noted that the setback distance is denoted as “to be verified” in the forthcoming subsurface facility system description document.)

Following additional discussions, the NRC asked for clarification on two issues: (1) when screening FEPs, is the screening process done event by event, or is the screening process done by classes of events; and (2) does DOE consider the time period beyond 10,000 years when screening FEPs? Although NRC’s proposed 10 CFR Part 63 time period of regulatory interest does not extend beyond 10,000 years, the NRC did note that it would conduct its analyses beyond 10,000 years so as to better inform its reasonable assurance decision. DOE stated that it is attempting to develop consequence arguments to aid in the screening process and carry them through to total system performance. DOE stated that the screening process looks at FEPs one by one for 10,000 years. The TSPA nominal scenario is run for time periods beyond 10,000 years. DOE stated that it has no plan at this time to extend all the FEPs analyses past 10,000 years. Both NRC and DOE agreed that these two issues would be discussed again in the forthcoming TSPA KTI technical exchange. Following additional discussions, the NRC clarified that proposed 10 CFR Part 63 does not have a requirement for performance analyses for the period beyond 10,000 years.

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

4) Technical Discussion - Subissue #4, Tectonic Framework

A summary of the current status of resolutions was presented (see “Subissue #4: Structural Deformation and Seismicity - Tectonic Framework” presentation given by Carl Stepp). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criteria. The matter of “consistency of treatment of tectonic models in PSHA and PVHA” was discussed by DOE in the Igneous Activity (IA) technical exchange (see IA summary highlights dated August 31, 2000). DOE re-emphasized the technical basis for resolution by reiterating that the so-called “hinge line” is not a structural barrier that delineates the volcanic source zone; and volcanic source zones do not represent seismogenic sources as used in the PSHA.

As a result of these discussions, the NRC stated that DOE had provided the necessary information and needed clarifications. Therefore, the NRC stated that Subissue #4 is closed.

5) Technical Discussion - Subissue #2, Seismicity

A summary of the current status of resolutions was presented (see “Subissue #2: Structural Deformation and Seismicity - Seismicity” presentation given by Richard Quittmeyer). There are six acceptance criteria (excluding QA), all of which are considered to be either closed or closed-pending by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and subsequent NRC/DOE discussions for

each acceptance criteria. DOE then addressed these needs during discussions of each acceptance criteria.

DOE stated that all of the additional information needed by the NRC will be included in the update to the FEPs AMR, the seismic design input report, and the seismic topical report 3. The NRC had questions regarding the seismic design input report, the DOE stated that the seismic design input report would be part of the basis for data inputs to the seismic topical report 3.

The NRC raised additional questions related to the use of the median versus the mean for probabilistic ground motions at low probabilities. DOE offered the same argument as in the faulting subissue, that the median more accurately reflects the central tendency of the probability distribution (see discussion in the faulting subissue).

The NRC had questions regarding the approach applied to evaluate seismic risk, including the assessment of seismic fragility and evaluation of event sequences. The NRC commented that no documentation has been provided that describes the approach to be used to evaluate the seismic fragility of components and a systems analysis that identifies the set of event sequences (including multiple hazards) that can occur. It was requested that DOE provide information in this area that describes their seismic probabilistic risk assessment methodology, its application to screening issues, and other topics.

Regarding ground motion, the NRC had questions about the PSHA expert elicitation process, specifically the issue of feedback to the subject matter experts following the elicitation of their respective judgements. DOE stated that they would provide the information requested.

The NRC also questioned the multiple definitions of the term “event.” DOE stated that in the update to the FEPs AMR, the term “events” would be defined, and used in a manner that is consistent with other documents.

Following additional discussions, the NRC asked for clarification regarding the six metric ton rock fall design basis event. DOE stated that the design basis for exclusion of rockfall in the drip shield design is that this is the bounding rock size for impact loads on the engineered barrier system (EBS). DOE noted that their design criteria were such that the EBS would be constructed to withstand rockfall from the largest impact loads possible from blocks falling on the emplacement drifts. Therefore, consideration of rockfall is excluded from the post-closure performance assessment.

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

6) Technical Discussion - Subissue #3, Fracturing

A summary of the current status of resolutions was presented (see “Subissue #3: Structural Deformation and Seismicity - Fracturing and Structural Framework” presentation given by Steve Beason, Jennifer Hinds, and Dwayne Kicker). There are six acceptance criteria (excluding QA), all of which are considered to be closed by the DOE. DOE then identified the NRC information needs from Revision 2 of the SDS IRSR, the April 2000 KTI technical exchange, and

subsequent NRC/DOE discussions for each acceptance criterion. DOE then addressed these needs during discussions of each acceptance criteria.

NRC staff were concerned that some of DOE's justifications of fracture-related issue closures were based on assertions of conservatism. The bases for these assertions are beyond the scope of this technical exchange and will be addressed under Unsaturated and Saturated Flow Under Isothermal Conditions (USFIC), Repository Design and Thermal-Mechanical Effects (RDTME), Thermal Effects of Flow (TEF), Radionuclide Transport (RT), and Evolution of the Near-Field Environment (ENFE) KTI's as appropriate.

NRC agreed with DOE that fracture aperture data are not critical to rockfall analysis. NRC pointed out the apparent disparity between the apertures of measured fractures (≥ 0.2 mm) and the fractures considered important to flow modeling <0.2 mm (200 microns). DOE responded by asserting that there are no field methods to measure apertures <0.2 mm. Also, the unsaturated zone models are mostly based on air permeability and moisture content data and do not depend on fracture geometry data.

NRC suggested that hydraulic apertures determined from air permeability tests would be controlled by constrictions of the flow path. Consequently average aperture over the flow pathway may be underestimated. Using the active fracture model assumptions in which mobile water exists in connected, locally saturated aperture segments which could overestimate fracture/matrix interface area. DOE responded that aperture is not important in the active fracture model.

NRC expressed concern that fracture porosity (and aperture) measurements through pneumatic and gas tracer testing inherently measure dry, well-connected, and largest-aperture fractures. Small-aperture and water-filled fractures, which are those that are expected to transport water in the unsaturated zone under ambient conditions and considered to be important to unsaturated zone flow modeling, may not be captured by air permeability testing. DOE responded that the pneumatic tests are sensitive to fracture networks at varying scales, including small aperture fractures.

NRC expressed concern that there is an apparent inconsistency between assumption of 100% fracture connectivity and observations of localization of CI-36 anomalies at repository depths. The DOE indicated that 100% fracture connectivity was realistic and did not contradict CI-36 anomalies. The 100% connectivity refers to the extensive interconnected network of smaller-scale fractures that pervade the welded tuffs. Large-scale pneumatic tests clearly show the interconnectivity of these units. DOE noted that the CI-36 data show that fast paths may exist through the nonwelded Paintbrush Tuff via major faults as the elevated CI-36 is associated with these major faults.

NRC expressed concern that fracture connectivity has not been investigated systematically. In response, DOE described two stratigraphic boundaries in the Topopah Spring Tuff where abrupt and consistent terminations of fractures occur. In further response to NRC questions, the DOE said that fracture data for Calico Hills Formation comes from three wells, and one air permeability test (UZ-16). Wells SD-12 and UZ-16 penetrated the entire Calico Hills Formation and NRG7 penetrated only the upper Calico Hills Formation. DOE confirmed that data from

Calico Hills Formation (and lower units) is limited and stated that they have used conservative assumptions in the unsaturated zone flow model to account for the sparse data.

NRC questioned the technical basis for the active fracture model. For example, are the mineralized (calcite, opal) fractures those that carry the water, or are the mineralized fractures those where flow rate is low and significant evaporation occurs? The role of mineralized fractures with respect to unsaturated zone flow has been addressed for USFIC by DOE's agreement to perform the Alcove 8-Niche 3 test. DOE recently provided plans for this test and the NRC staff has provided review comments. This topic will be further addressed by RT as needed.

NRC commented that the assumption of lateral flow in the Calico Hills seems inconsistent with the assumption of no lateral flow in the Paintbrush Tuff-nonwelded unit. Furthermore, CI-36 which is focused in zones up to 200 m wide (perpendicular to faults) in ESF is indicative of lateral diversion beneath PTn. This may be particularly important for the question of infiltration along the west flank of Yucca Mountain, and lateral flow towards the proposed repository emplacement area. DOE stated that they have no data to evaluate recharge from Solitario Canyon, but acknowledged that they had not yet investigated this in the flow model, and while not in FY2001 budget, it may be studied in the future. The NRC staff noted this issue will be addressed by the long-term passive test in the cross drift if the test tunnel is allowed to return to ambient conditions. The western-most part of the isolated cross drift should show whether percolation is enhanced by lateral flow from recharge along the western slope of Yucca Mountain.

In response to a query from the NRC, DOE noted that the unsaturated zone flow model for TSPA-VA did not include the hydrology of the Abandoned Wash fault. DOE indicated that the Unsaturated Zone Flow Model, Revision 1, does evaluate the Abandoned Wash fault.

The DOE indicated that the fracture hydraulic properties (e.g., alpha parameter) active fracture model parameter was not sensitive to small changes in fracture frequency that would be derived from sampling bias correction (e.g., a 10% increase in the number of fractures).

NRC agreed that fracture origin is not directly linked to performance.

NRC suggested, in the absence of direct measurements of fracture characteristics, DOE should provide a technical basis for fracture-related parameters used in process models. This topic will be further pursued in the USFIC, RDTME, TEF, ENFE, and RT KTI's. USFIC has emphasized the need for DOE to complete the Alcove 8 - Niche 3 test and the long-term passive test in the cross drift. These tests should be used to calibrate unsaturated zone models of seepage.

NRC staff commented that they are concerned that length bias for largest fractures from tunnel data has not been corrected by the analysis of the full periphery geometric mapping data. This concern will be addressed by review of the Fracture Geometry in Key Stratigraphic Units in the Repository Host Horizon (ANL-EBS-GE-000006) AMR.

NRC staff raised the concern that isotropic permeability is still being used in one of two models for modeling flow and radionuclide transport in the saturated zone. The anisotropic model has an established technical basis and is supported by C-well data. DOE pointed out that the NRC

analysis of C-well data is poorly constrained and could be interpreted to cover a wide range of anisotropy. DOE's approach is to use alternate conceptual models that are treated as being equally probable - one with laterally anisotropic permeability and the other treated as anisotropic. This issue is to be pursued further in the Saturated Zone technical exchange of the USFIC KTI.

NRC staff's concerns regarding seismic and thermal effects on rockfall will be pursued under the RDTME KTI.

The NRC noted that the DOE assumptions that fracture diameters are 4X the trace length of all fractures measured in detailed line surveys (DLS) including those abutting other fractures may result in underestimation of block size. DOE reiterated that this approach is conservative. This issue will be addressed in the RDTME technical exchange.

NRC questioned modeling of a 1-m thick excavation induced disturbed zone with increased permeability around drifts which is discussed in the Seepage Calibration Model and Seepage Testing Data (MDL-NBS-HS-00004) AMR. DOE said that the model was based on measurements of air permeability enhancement, which it assumes to be the effect of unloading-induced dilation of existing fractures, rather than the formation of new fractures. DOE addressed this by agreeing to provide a writeup about excavation-induced fractures.

The NRC stated that in pre-technical exchange conference calls, a consolidated report on fractures was discussed. Although it is not a necessity, the NRC stated that it would enhance the review of numerous process models for consistency with site conditions and transparency of the review.

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

7) Public Comments

Ms. Treichel (Nevada Nuclear Water Task Force) had questions/comments regarding (1) the inconsistency in information presented at previous KTI meetings associated with rockfall; (2) the use of proposed 10 CFR Part 63; and (3) whether rockfall will be addressed in pre-closure discussions. Specifically, Ms. Treichel (1) stated that a 13 ton rock was discussed in the Container Life and Source Term technical exchange and a 6 ton rock was discussed in the SDS discussions; (2) stated that references to 10 CFR Part 63 should not be made during these meetings since Part 63 has not been approved, instead reference should be made to Part 60; (3) questioned whether rockfall is just a post-closure issue or if it will be addressed in pre-closure discussions.

Regarding (1), DOE noted that there had been an evolution in decision-making regarding the design-basis rockfall to be considered in repository design. The original 13-ton design basis was based on older DOE design documents. Subsequent drift degradation analysis yielded smaller block-size distributions on the order of 6 tons - the current design basis as a result of drift reorientation. The NRC noted that it had additional questions regarding the rockfall issue, but that the questions would be raised in the Repository Design and Thermal-Mechanical

Effects technical exchange. Regarding (2), this comment was noted without response. Regarding (3), the NRC stated that rockfall will be addressed in pre-closure discussions, specifically within the RDTME KTI technical exchange. DOE stated that ground supports should ensure safety during the pre-closure period.

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