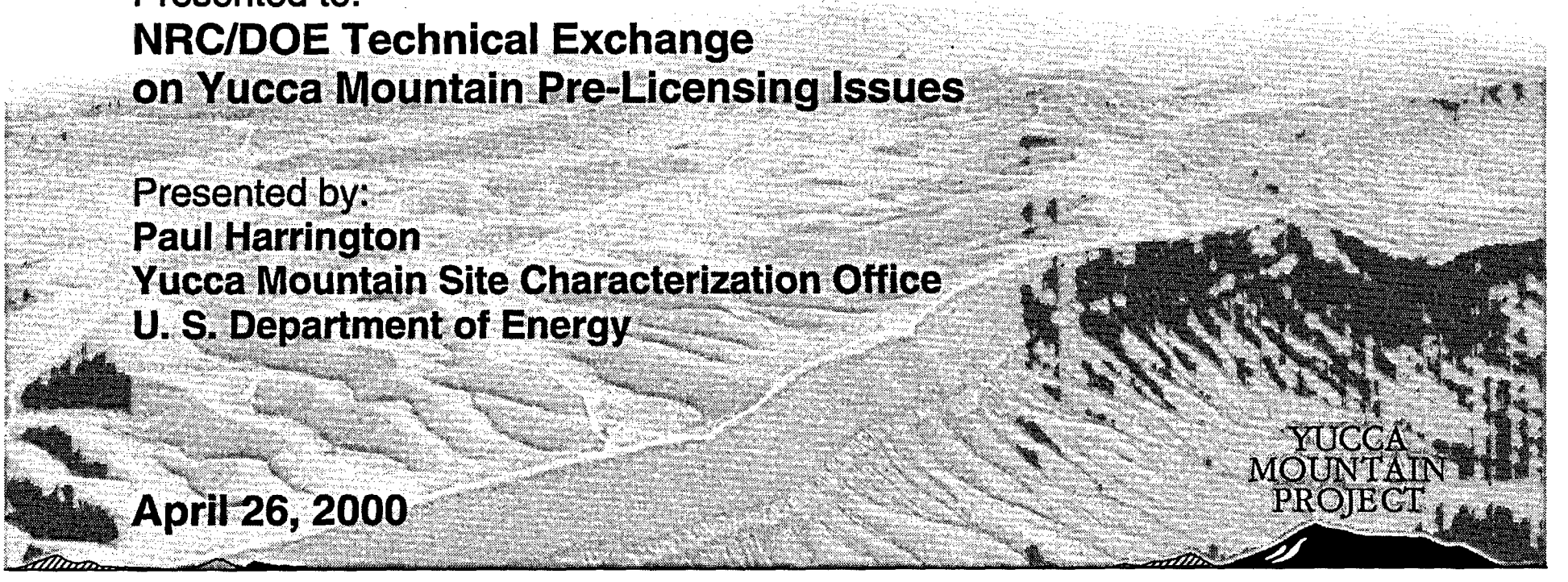
[13]

U.S. Department of Energy
Office of Civilian Radioactive Waste Management

Repository Design and Thermal-Mechanical Effects

Presented to:
NRC/DOE Technical Exchange
on Yucca Mountain Pre-Licensing Issues



Presented by:
Paul Harrington
Yucca Mountain Site Characterization Office
U. S. Department of Energy

April 26, 2000

Legacy/main - rd

Current Status

(Issue Resolution Status Report Revision 2)

- **Subissue 1 - Design Control (Quality Assurance Program)**
  - **Most of acceptance criteria have been evaluated satisfactorily**
  - **DOE has taken action related to the one concern expressed**
- **Subissue 2 - Effects of Seismic Events and Direct Fault Disruption**
  - **Seismic Topical Report-1 and -2 (Components 1 and 2) have been provisionally accepted pending review of Seismic Topical Report-3**
  - **DOE agrees with criteria of Component 3 (Seismic Topical Report-3)**

DOE feels they need more field testing work to support

Current Status

(Issue Resolution Status Report Revision 2)
(Continued)

- **Subissue 3 - Thermal-Mechanical Effects on Underground Facility Design and Performance**
  - **No criteria are closed. NRC has reviewed many of the criteria and deferred others**
  - **A valuable Appendix 7 meeting was held in November 1999**
  - **Additional interactions probable after NRC reviews DOE's letter of 3/00**
- **Subissue 4 - Design and Long-Term Contribution of Seals to Performance**
  - **NRC has not yet developed related acceptance criteria**
  - **DOE classifies seals as non-Q and does not relate the seals to postclosure performance**

Key Activities

- **Fiscal Year (FY) 1998**
  - Appendix 7 meeting June 1998 to evaluate design control acceptance criteria
  - NRC found Seismic Topical Report-2 acceptable (pending review of Seismic Topical Report-3)
  - Completed analyses that identified three options for ground support for emplacement drifts (pre-cast concrete, cast-in-place concrete, and steel sets and lagging)
  - Completed preliminary block size calculation

Key Activities
(Continued)

- **FY 1999**
  - Issued Viability Assessment (VA), which reflected three options for ground support for emplacement drifts
  - Disqualified use of concrete for emplacement drifts ground support (uncertainties regarding the potential effects of concrete on migration of contaminants released from waste packages)
  - Decided to use carbon steel for ground support (steel sets and wire mesh, supplemented by grouted rockbolts where necessary)
  - Completed analyses of rockfall on different waste package design concepts. Selected design using corrosion-resistant material

Key Activities
(Continued)

- **FY 1999** (Continued)
  - Completed analysis for the rockfall on corrugated drip shield design
  - Performed preliminary key block analysis for the static case. Completed a design basis block size assessment based on preliminary fracture data

Key Activities
(Continued)

- **FY 2000**
  - Held Appendix 7 meeting November 1999 on thermal-mechanical analyses of emplacement drifts, data, model development, and application of results
  - Completed analysis of emplacement drifts ground support (steel sets and wire mesh supplemented by grouted rockbolts) in support of the Site Recommendation Consideration Report
  - Modified rockfall analysis methodology based on more detailed rock geometry input
  - Completed drift degradation analysis that included a modified approach for assessing seismic and time-dependent joint degradation effects on block size

looking at 3 m liftfield and 10 ton rock

Key Activities
(Continued)

- **FY 2001**
  - Plan to perform analyses to develop preliminary designs for steel sets, wire mesh, and grouted rockbolts for License Application
  - Plan to analyze results of in situ (heated) tests for confirmation or adjustment of design parameters and analysis procedures
  - Plan to examine multiple rockfall scenario if determined to be a credible event

KTI Subissues and Associated Factors of the Safety Case

	KTI Subissues	Associated Factors of the Safety Case	Importance to Repository Performance
1	Implementation of an Effective Design Control Process within the Overall Quality Assurance Program	All	Quality assurance program will be applied.
2	Design of the Geologic Repository Operations Area for the Effects of Seismic Events and Direct Fault Disruption	Waste package degradation/performance and drip shield degradation/performance	These elements will be designed to withstand design seismic events.
3	Thermal-Mechanical Effects on Underground Facility Design and Performance	Waste package degradation/performance and drip shield degradation/performance	These elements will be designed to withstand the design-basis rockfall.
4	Design and Long-Term Contribution of Repository Seals in Meeting Postclosure Performance Objectives	None ~ based on water flow and seals preventing water flow into repository	Not considered important to repository performance.

Subissue 1: Implementation of an Effective Design Control Process within the Overall Quality Assurance Program

- Acceptance criteria are included as elements of the quality assurance (QA) program
- QA program is implemented by the *Quality Assurance Requirements and Description* Document, accepted by NRC
- NRC satisfied with implementation of most criteria during review of June 1998
- Individual QA program concerns being addressed separately

Subissue 1: Implementation of an Effective Design Control Process within the Overall Quality Assurance Program

(Continued)

- The single concern expressed in the Issue Resolution Status Report (IRSR) has been addressed by DOE
  - Investigated extent of problem, issued Lessons Learned
  - Performed self-assessment, issued deficiency report
  - Status provided to NRC in DOE comment letters on IRSR
  - Deficiency report closed 3/00

Subissue 2: Design of the Geologic Repository Operations Area for the Effects of Seismic Events and Direct Fault Disruption

- Approach to subissue resolution is through a series of three seismic topical reports
- Seismic Topical Report-1 and Seismic Topical Report-2 have been provisionally accepted pending review of Seismic Topical Report-3
- Seismic Topical Report-3 is expected to be delivered for review in November 2001

Subissue 3: Thermal-Mechanical Effects on Underground Facility Design and Performance

- **Three Major Components**
  1. **Thermal-Mechanical Effects on Design of Underground Facility**
  2. **Effects of Seismically Induced Rockfall on Waste Package Performance**
  3. **Thermal-Mechanical Effects on Flow into Emplacement Drifts**

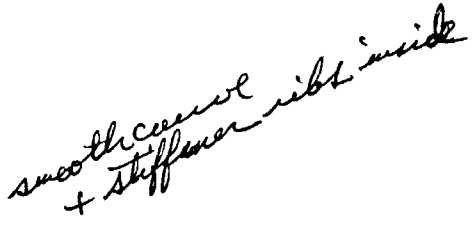
Thermal-Mechanical Effects on Design of Underground Facility

- Divergence of opinion related to predicted rock mass friction angles (IRSR, Section 4.3.3.2)
- DOE estimated rock mass properties based on geotechnical mapping of the rock mass following guidelines described by Hoek and Brown
- IRSR reports discrepancy in rock mass friction angles
  - DOE values: 57° to 58°
  - NRC values: 28° to 35°

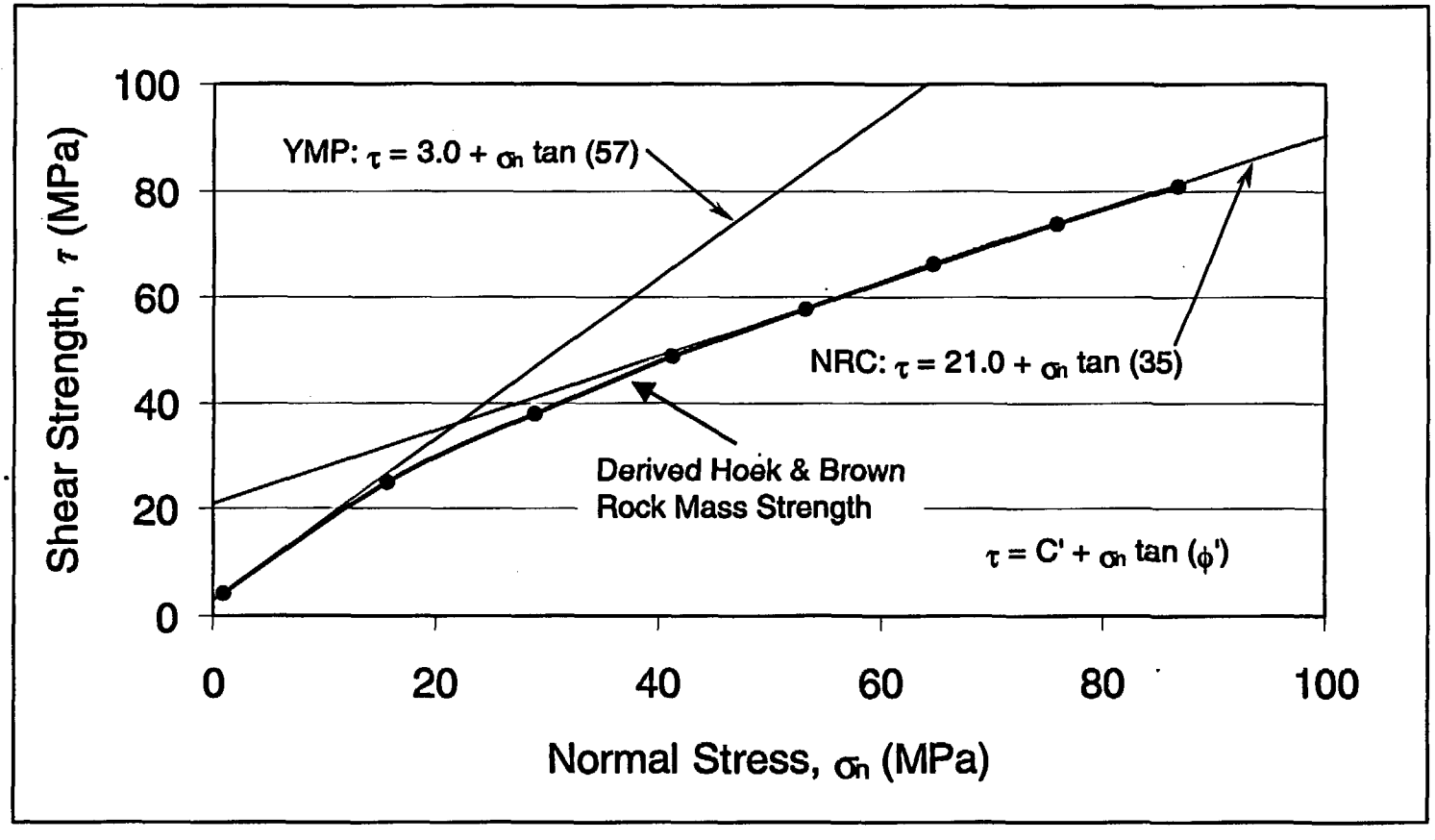
Thermal-Mechanical Effects on Design of Underground Facility

(Continued)

- DOE/NRC basic approach to assessing rock mass friction angle is the same. The difference is in the stress range over which the friction angles were calculated
- DOE letter to NRC of 3/00 addresses in detail



Shear Strength Curve Based on the Hoek and Brown Approach (GSI=62, σ_{ci} =167.9 MPa, m_i=19.68)



GSI – Geological Strength Index σ_{ci} – intact rock unconfined compressive strength
m_i – Hoek and Brown rock mass strength parameter

Determination of Seismically Induced Rockfall on Waste Package Performance

- At Appendix 7 meeting in November 1999, NRC staff expressed concern related to a need for additional dynamic analyses to validate the existing approach
- Current drift degradation analysis
  - Based on VA emplacement drift alignment
  - Includes backfill
- New calculation (March 2000 - in review) includes revised block sizes based on new emplacement drift alignment and excludes backfill

Design requirement stay a certain orientation away from dominant joint set → determined using main loop tunnel mapping

change 36°

Determination of Seismically Induced Rockfall on Waste Package Performance

(Continued)

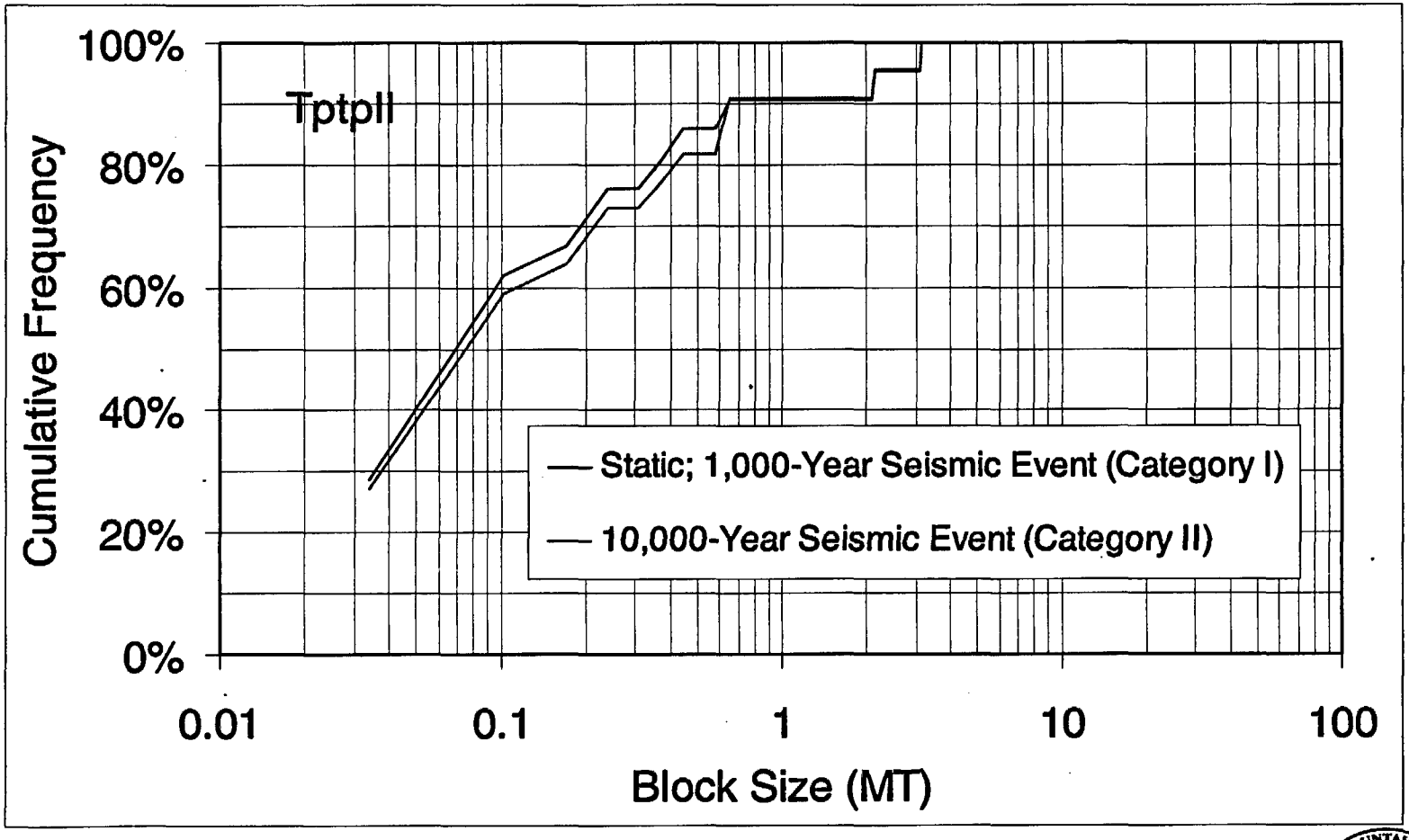
- **Planning under development for revised drift degradation analysis**
  - **Will include current emplacement drift alignment and exclude backfill**
  - **Will consider additional dynamic analyses for seismic effects on rockfall**

Determination of Seismically Induced Rockfall on Waste Package Performance

(Continued)

- **Quasi-static approach to drift degradation analysis**
  - Assemble related site data (joint geometrical data, joint frictional properties, fallen blocks, rock properties from laboratory tests of borehole samples)
  - Analyze the joint data to assess the potential formation of key blocks and the seismic and thermal effects on joint and block movement
  - Determine the number and average mass of rockfall per unit length of drift for various levels of seismic hazard and the distribution data for each lithologic unit
  - Analyze the drift profile showing the progressive movement of joints and blocks with time and establish basis for block size criteria for subsurface facilities and waste package design

Cumulative Size Key Block Distributions for Tptpll Unit (Seismic Case, Current Emplacement Drift Alignment)



Predicted Number of Key Blocks per Unit Length (km) along Emplacement Drift (Seismic Consideration, Current Emplacement Drift Alignment)

Lithologic Unit	Emplacement Drift Length (%)	Static	Static Plus Seismic 1,000 year (Category I)	Static Plus Seismic 10,000 year (Category II)
Tptpmn	7	28	29	32
Tptpll	78	2	2	2
Tptpln	15	6	7	7

- **Drift degradation analysis revision will include additional dynamic analyses to confirm results of the current methodology**

Subissue 4: Design and Long-Term Contribution of Repository Seals in Meeting Postclosure Performance Objectives

- Acceptance criteria are not yet developed for this subissue in the IRSR
- Based on work done to date:
  - This subissue includes no factors demonstrated to be important to waste isolation in the Repository Safety Strategy
  - Seals are classified as CQ (Conventional Quality), not subject to QA program
  - Work continues to evaluate other aspects of seal performance

Summary

- **Areas of agreement**
  - **Subissues 1 and 2 criteria**
  - **Subissue 4 – NRC acknowledges DOE work to identify importance of seals**
- **Areas of potential disagreement**
  - **Aspects of Subissue 3 addressed in Brocoum letter to Reamer of 3/00. For example:**
    - **Need for repository-scale modeling (IRSR, Section 4.3.3.1, Criteria 8, and Section 5.3.1.8)**
    - **Magnitude of predicted rock mass friction angles**
  - **Specific approach to individual analyses (possible topics for Appendix 7 meetings)**

Summary
(Continued)

- Subissue 1, Design Control, will be applied as established by the QA program
- Subissue 2, Design for the Effects of Seismic Events and Direct Fault Disruption, is being addressed mostly through a series of topical reports
- Subissue 3, Thermal-Mechanical Effects on Underground Facility Design and Performance, is being addressed by DOE, with specific areas of divergence to be discussed in Appendix 7 meetings

Summary
(Continued)

- **Subissue 4, Design and Long-Term Contribution of Repository Seals in Meeting Postclosure Performance Objectives, is addressed, although evaluation of certain aspects continues**

Backup

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
Subissue 1 - Effective Design Control Process within Quality Assurance		
1) The applicable regulatory requirements are identified.	Evaluated - Generally satisfactory	Implemented
2) The design bases associated with the regulatory requirements are defined.	Evaluated - Generally satisfactory	Implemented
3) The regulatory requirements of Acceptance Criteria 1 and the design bases of Acceptance Criteria 2 are appropriately translated into specifications, drawings, procedures, and instructions.	Evaluated - Generally satisfactory	Implemented
4) Appropriate quality standards are specified in the design documents.	Evaluated - Generally satisfactory	Implemented
5) Any deviations from the standards specified under Acceptance Criteria 4 are properly controlled, documented, and justified.	Evaluated - Generally satisfactory	Implemented
6) Measures are established for selection of materials, parts, equipment, and processes that are essential to functions of structures, systems, and components that are important to safety and waste containment and isolation.	Evaluated - Generally satisfactory	Implemented
7) Design interfaces are identified, controlled, and appropriately coordinated among participating design organizations.	Evaluated - Generally satisfactory	Implemented
8) Procedures are established for review, approval, release, distribution, and revision of documents involving design interfaces.	Evaluated - Generally satisfactory	Implemented
9) Measures are established for verifying or checking the accuracy of design calculations (e.g., performing design reviews using alternate or simplified calculational methods).	Evaluated - Generally satisfactory	Implemented
10) If testing is employed for verification of design adequacy for its intended service life, the testing is conducted under the most adverse conditions.	Limited evaluation. No concerns expressed.	Implemented

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
11) The design verification is conducted by independent and qualified professionals who did not participate in the original design efforts.	Evaluated - Generally satisfactory	Implemented
12) In addition to being applied to the original design, the design control process is also applied to design changes and to field changes, and these changes are properly documented.	Evaluated - Concern identified	Implemented. Concern identified was investigated by DOE, corrective action initiated, and related corrective action taken.
Subissue 2 Seismic Design Methodology (Part 1)		
1) The topical report addresses all important-to-safety (or important-to-waste-isolation) topics pertaining to the scope of the topical report.	NRC agreed that the issue of seismicity and fault displacement is an appropriate one to be dealt through the topical report process. Seismic Topical Report (STR) -1 and STR-2 have been provisionally accepted pending review of STR-3.	Agree
2) The subject of the topical report is currently undergoing pre-licensing evaluation.		
3) NRC's acceptance of the topical report would result in increased efficiencies in the staff review of DOE's license application.		
4) The topical report contains complete and detailed information on each element of the scope of the report.		
Subissue 2 Seismic Design Methodology (Part 2)		
1) Sufficient technical reasoning is provided for the proposed methodology.	No further questions at this time related to STR-1 and STR-2. These have been found acceptable to the staff pending review of STR-3. Final resolution after review of STR-3. Implementation of the design methodology will be monitored during the LA review.	Agree
2) If available, documented case histories of the performance of structures, systems, and components important to safety designed using the proposed methodology are presented in the topical report. In the absence of documented case histories, no serious problems have been identified that would impede applying the methodology.		

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
3) The proposed methodology does not contradict established methodologies and principles tested and documented in the license applications for nuclear power plants and independent spent fuel storage installations.	No further questions at this time related to STR-1 and STR-2. These have been found acceptable to the staff pending review of STR-3. Final resolution after review of STR-3. Implementation of the design methodology will be monitored during the LA review.	Agree
4) Uncertainties associated with the proposed methodology that would significantly affect or impede the repository design process and development of inputs to performance assessments have been considered adequately.		
5) The various steps involved in the proposed methodology are transparent.		
6) To the extent that the proposed design methodology depends on site-specific test data, such data are available now, are being gathered now, or there are plans for gathering such data during site characterization and before submittal of the license application.		
7) To the extent that the proposed methodology depends on analytical/computer models, such models have been verified, calibrated, and validated to the extent practical, or there are plans for such activities prior to license application submittal or during the performance confirmation period, as appropriate.		
8) Any major assumptions or limitations to the proposed methodology are identified, and the implications regarding design and performance are discussed in the topical report.		
9) The contents of TR-2 are consistent with the contents of TR-1 and, taken together, the two topical reports support the development of inputs for design and performance assessments, as described in TR-3.		

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
Subissue 3: Thermal-Mechanical Effects		
Component 1: Thermal-Mechanical Effects on Design of the Underground Facility		
1) Approved quality assurance and control procedures and standards are applied to collection, development, and documentation of data, methods, models, and codes.	Review methods are under development. NRC will continue to participate as observers in DOE audits and surveillance to ensure implementation.	This criterion is met. Collection of data, development of analyses and models, and use and validation of software is subject to the requirements of procedures developed to implement quality assurance program requirements.
2) If used, expert elicitations are conducted and documented in accordance with the guidance in NUREG-1563 or other acceptable guidelines.	Review methods are under development. NRC will continue to participate as observers in DOE audits and surveillance to ensure implementation.	This criterion is met. Expert elicitations are conducted in accordance with the requirements of the QA program which incorporates, in part, the guidance of NUREG-1563.
3) Thermal-mechanical analyses of the repository design are based on site-specific thermal and mechanical properties, spatial variation of such properties, and temporal variations caused by post-emplacement thermal-mechanical-hydrological-chemical processes, as appropriate, including consideration of seismic effects relevant to the Yucca Mountain site within the rock-mass.	Review methods are under development. NRC will continue to participate as observers in DOE audits and surveillance to ensure implementation. This was indicated as an area for discussion at an Appendix 7 meeting.	DOE includes site-specific information in its analyses, when applicable. An Appendix 7 meeting was held in November 1999 that included discussions of this criterion. Agreement was not reached related to DOE's use of lower stress values.
4) The process to develop inputs to thermal-mechanical design includes consideration of associated uncertainties and documents the potential impacts on design.	IRSR expressed need for an Appendix 7 meeting to discuss validation of empirical equations	Uncertainties are fully considered and documented. An Appendix 7 meeting was held in November 1999 that included discussions of this criterion.

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
5) The seismic and fault-displacement data inputs for design are consistent with those established in seismic design TR-3.	Will be addressed when STR-3 is reviewed and data is used in the design.	STR-3 is currently planned for submission to NRC in November 2001. Agree
6) The methodologies used for the thermal-mechanical design and analyses are consistent with those established in DOE Seismic TR-2.	Awaits design details that will be provided in the SR and LA.	Methodologies are and will be consistent with those identified in STR-2. Agree
7) The thermal-mechanical design and analyses make use of appropriate constitutive models that represent jointed rock mass behavior under prolonged heated conditions. These models are tested as appropriate (verified, validated, and calibrated) to the extent practicable before the submittal of the license application. (For those aspects of the models for which long-term experimental data are needed, continued verification and validation during performance confirmation are considered acceptable as long as detailed plans and procedures for such continued activities are found in the license application.)	Anticipates further review in FY 2000. This was indicated as an area for discussion at an Appendix 7 meeting.	This criterion is met. The Performance Confirmation Plan describes the currently-identified confirmation activities that will be conducted. An Appendix 7 meeting was held in November 1999 that included discussions of this criterion.
8) Both drift- and repository-scale models of the underground facility are used in thermal-mechanical analyses to establish the intensity and distribution of ground movement (rock deformations, collapse, and other changes that may affect the integrity or geometrical configuration of openings within the underground facility). The number and variety of models permit the examination of conditions along drift-parallel and drift-normal directions.	NRC will continue to follow DOE's progress in this area. This was indicated as an area for discussion at an Appendix 7 meeting.	DOE has suggested a revision to the wording of the criterion to remove the mandate to develop repository-scale models. To date, DOE has not identified problems that require a full-scale repository model. Drift-scale models have been developed that represent the range of expected repository conditions, and modeling has been developed to examine limiting or bounding conditions. An Appendix 7 meeting was held in November 1999 that included discussions of this criterion.

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
9) The principles formulating the thermal-mechanical analytical methodology, underlying assumptions, resulting limitations, and various steps involved in the design procedures are clearly explained and justified.	Anticipates further review in FY 2000.	This criterion is met. Agree
10) Time sequences of thermal loading used in thermal-mechanical design and analyses are clearly defined.	Will follow developments based on changes to designs	This criterion is met. Agree
11) The thermal-mechanical design and analyses consider the presence of roof supports (bolts, shotcrete, concrete, and steel liners, as applicable), consider the interaction between rock and roof supports, and address the degradation of supports with time under high temperature and moisture conditions as they affect the maintainability of stable openings during the extended preclosure period.	This was indicated as an area for discussion at an Appendix 7 meeting.	This criterion is met. An Appendix 7 meeting was held in November 1999 that included discussions of this criterion.
12) The results of the thermal-mechanical analyses, including the consideration of ground support (e.g., liners), are accounted for in the determination of maintenance requirements for the underground facility.	This is a topic for future review when DOE develops related requirements.	Agree
13) The design discusses maintenance plans for keeping the underground openings stable, with particular attention to maintaining the option for retrieval. (If the details of retrieval operations/plans are found in other sections of the license application, a reference to such sections would be acceptable.)	Review will be done when pertinent sections of the LA are reviewed.	Agree

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
Component 2: Effects of Seismically Induced Rockfall on Waste Package Performance		
1) Approved quality assurance and control procedures and standards are applied to collection, development, and documentation of data, methods, models, and codes.	Evaluation is deferred until the relevant DOE audit is conducted.	This criterion is met. Collection of data, development of analyses and models, and use and validation of software are subject to the requirements of procedures developed to implement quality assurance program requirements.
2) If used, expert elicitation is conducted and documented in accordance with the guidance in NUREG-1563 or other acceptable approaches.	Will review in conjunction in FY 2000 with the related criterion in the KTI on Structural Deformation and Seismicity.	This criterion is met. Expert elicitations are conducted in accordance with the requirements of the QA program, which incorporates, in part, the guidance of NUREG-1563.
3) The seismic hazard inputs used to estimate rockfall potential are consistent with the inputs used in the design and performance assessments as established in DOE's TR-3 reviewed and accepted by NRC.	The effect on waste package damage of the revisions to the exceedence curve for horizontal PGV needs to be evaluated.	Inputs are based on preliminary design basis seismic ground motion parameters. Updates addressing the postclosure earthquake will be performed as needed using guidance presented in the STRs.
4) Size distribution of rocks that may potentially fall on the waste packages is estimated from site-specific data (e.g., distribution of joint patterns, spacing, and orientation in three dimensions) with adequate consideration of associated uncertainties.	Evaluation will continue when additional work is done by DOE.	This criterion is met. Drift degradation analysis is based upon a probabilistic key block analysis. The key block analysis is based upon the collection of data for joint patterns, spacing, and orientation from underground detailed line surveys conducted in the ESF main loop and the ECRB cross drift. The joint data is analyzed statistically to account for uncertainties in joint properties.

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
5) The analytical model used in the estimation of impact load due to rockfall on the waste package is: (i) based on reasonable assumptions and site data; (ii) consistent with the underground facility (emplacement drift geometry and backfill) and waste package designs; and (iii) defensible with respect to providing realistic or bounding estimates of impact loads and stresses.	The approach is acceptable, with a few concerns to be addressed.	This criterion is met. For information, based on current design, rockfall will not result in rock hitting the waste package. The drip shield is substantial enough to absorb or deflect rockfall to prevent it from contacting the waste package.
6) The thermal-mechanical analyses that provide the background conditions on which seismic loads are superimposed consider time-dependent jointed rock behavior.	The TSPA-VA rockfall models do not consider the potential effect of time-dependent jointed rock behavior. Review will occur as new documents are produced.	This criterion is met. Drift degradation analysis considers the change in rock mass properties due to thermal loading. The analysis accounts for time-dependent and thermal effects with joint cohesion degradation.
7) Rockfall analyses consider, in a rational and realistic way through dynamic analyses, the possibility of multiple blocks falling onto a waste package simultaneously, and the extent of potential rockfall area around an individual emplacement drift as well as over the entire repository as functions of ground motions.	Since larger rock blocks cause more damage to waste packages, mechanisms that may increase the "effective rock size" should be considered in the model (e.g., potential for rock blocks located one above the other to fall in unison).	DOE has considered multiple blocks falling at one location. Current position is that the largest single block represents the most conservative impact load. More work is needed to assess the possibility of multiple rock impact and waste package responses.
Component 3: Thermal-Mechanical Effects on Flow Into Emplacement Drifts		
1) Approved quality assurance, control procedures, and standards, were applied to collection, development, and documentation of data, methods, models, and codes.	Evaluation is deferred until the relevant DOE audit is conducted.	This criterion is met. Collection of data, development of analyses and models, and use and validation of software is subject to the requirements of procedures developed to implement quality assurance program requirements.

Key Technical Issue: Repository Design and Thermal-Mechanical Effects		
ACCEPTANCE CRITERIA	**RDTME IRSR Rev 2 Status**	**DOE Comment**
2) If used, expert elicitation is conducted and documented in accordance with the guidance in NUREG-1563 or other acceptable approaches.	To date no questions or comments regarding the use of expert elicitation related to this component have been raised. The expert elicitation process for the near-field/altered zone will be reviewed under the ENFE KTI.	This criterion is met. Expert elicitations are conducted in accordance with the requirements of the QA program which incorporates, in part, the guidance of NUREG-1563.
3) Time-dependent changes in size and shape of the emplacement drifts due to thermally induced ground movements (rock deformations, collapse, and other changes that may affect the integrity and geometrical configuration of underground openings) are estimated taking into account uncertainties in the context of their impacts on the performance.	Change in geometry' potential effect on dripping characteristics into emplacement drifts was not considered in TSPA-VA.	This criterion is met. Drift degradation analysis estimate time-dependent changes and take uncertainties into account.
4) Changes in hydrological properties (e.g., fracture porosity and permeability) due to thermally induced ground movements are estimated taking into account the uncertainties in the context of their impacts on performance.	Thermally and seismically induced ground movements will alter the hydraulic properties of the environment immediately next to the waste package. The RDTME KTI staff is working with the TEF KTI staff to evaluate the importance of such changes to the performance assessment.	This criterion is met. Calculations have been performed to estimate bounds on changes in fracture permeability in rock surrounding emplacement drifts.
Subissue 4: Design and Long-Term Contribution of Repository Seals in Meeting Postclosure Performance Objectives		
Criteria for this subissue have not yet been developed.	Initial limited analysis of unsealed open borehole scenario suggest that the contributions of seals to overall performance is small.	Based on work done to date, seals relate to no factors considered to be important in the Repository Safety Strategy. Seals are classified as CQ (Conventional Quality), not subject to QA program. Work continues to evaluate other aspects of seal performance.