

MAR 10 1993

NOTE FOR: Prasad K. Nair, Engineered Barrier System  
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FROM: Charles G. Interrante, NRC-Engineered Barrier System  
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 Geology and Engineering Branch  
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SUBJECT: TRANSMITTAL OF PRELIMINARY NRC STAFF APPROVAL OF THE  
 COMPLIANCE DETERMINATION STRATEGY FOR REVIEW PLAN 5.3:  
 ASSESSMENT OF COMPLIANCE WITH THE DESIGN CRITERIA FOR THE  
 POSTCLOSURE FEATURES OF THE UNDERGROUND FACILITY

The purpose of this note is to transmit the subject compliance determination strategy (CDS) that has received preliminary approval by the NRC staff. Final approval of the CDS is subject to our review and resolution of any comments or changes made by the Center for Nuclear Waste Regulatory Analyses.

Enclosures:  
 as stated

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**COMPLIANCE DETERMINATION STRATEGY  
REVIEW PLAN 5.3 ASSESSMENT OF COMPLIANCE WITH THE DESIGN CRITERIA  
FOR THE POSTCLOSURE FEATURES OF THE UNDERGROUND FACILITY**

**APPLICABLE REGULATORY REQUIREMENTS:**

10 CFR 60.21(c)(1)(ii)(D)  
10 CFR 60.21(c)(1)(ii)(E)  
10 CFR 60.21(c)(1)(ii)(F)  
10 CFR 60.21(c)(2)  
10 CFR 60.21(c)(3)  
10 CFR 60.21(c)(6)  
10 CFR 60.21(c)(14)  
10 CFR 60.133(a)(1)  
10 CFR 60.133(e)(2)  
10 CFR 60.133(f)  
10 CFR 60.133(h)  
10 CFR 60.133(i)

**TYPES OF REVIEW:**

Acceptance Review (Type 1)  
Safety Review (Type 3)

**RATIONALE FOR TYPES OF REVIEW:**

**Acceptance Review (Type 1) Rationale:**

This regulatory requirement topic is considered to be license application-related because, as specified in the license application content requirements of 10 CFR 60.21(c) and the regulatory guide "Format and Content for the License Application for the High-Level Waste Repository (FCRG)", it must be addressed by the U.S. Department of Energy (DOE) in its license application. Therefore, the staff will conduct an acceptance review of the license application for this regulatory requirement topic.

**Safety Review (Type 3) Rationale:**

This regulatory requirement topic is considered to be related to containment and waste isolation. It is a requirement for which compliance is necessary to make a safety determination for construction authorization as defined in 10 CFR 60.31(a) (i.e., regulatory requirements in Subparts E, G, H, and I). Therefore, the staff will conduct a Safety Review of the license application to determine compliance with this regulatory requirement topic.

This regulatory requirement topic focuses on postclosure aspects of compliance with the design criteria for the underground facility. Preclosure aspects of compliance with underground facility design criteria

are considered in Review Plan 4.4 ("Assessment of Compliance with Design Criteria for the Geologic Repository Operations Area (GROA) Underground Facility"). The "Assessment of Compliance with the Design Criteria for the Waste Package and its Components" is the subject of Review Plan 5.2. The "Assessment of Compliance with the Engineered Barrier System (EBS) Performance Objectives" is the subject of Review Plan 5.4. It is expected that the reviewers for each of these review plans will closely coordinate review activities to ensure consideration of closely related or overlapping details.

The description provided in Review Plan 5.1 ("Description of Engineered Systems and Components that provide a Barrier between the Waste and the Geologic Setting"), will form the basis for the Safety Review of this Review Plan. If it is determined that the information in Review Plan 5.1 is inadequate to support the Safety Review for this Review Plan, then additional information will be requested from DOE.

There appears to be no lack of certitude as to the methodology needed to determine or demonstrate compliance with the regulatory requirement topic for compliance with the design criteria for the postclosure features of the underground facility. A review of each citation from 10 CFR Part 60 that comprises this regulatory requirement topic indicates low risk of noncompliance with performance objectives as a result of technical uncertainty associated with the postclosure features of the following design requirements:

- (1) 10 CFR 60.133(a)(1) - The orientation, geometry, layout, and depth of the underground facility and the design of any engineered barriers that are part of the underground facility shall contribute to the containment and isolation of radionuclides.
- (2) 10 CFR 60.133(e)(2) - Openings in the underground facility shall be designed to reduce the potential for deleterious rock movement or fracturing of overlying or surrounding rock.
- (3) 10 CFR 60.133(f) - The design of the underground facility shall incorporate excavation methods that will limit the potential for creating a preferential pathway for groundwater to contact the waste packages or radionuclide migration to the accessible environment.
- (4) 10 CFR 60.133(h) - Engineered barriers shall be designed to assist the geologic setting in meeting the postclosure performance objectives for the period following permanent closure.

With respect to the requirement of 10 CFR 60.133(i) -- the underground facility shall be designed so that the performance objectives will be met taking into account the predicted thermal and thermomechanical response of the host rock, and surrounding strata, groundwater system -- there is an especially high risk of noncompliance due to uncertainties in predictions of thermal and thermomechanical response of the host rock and the surrounding geologic setting and groundwater system. However, for this requirement, the associated Key Technical Uncertainties are more aligned with Review Plan 5.4 ("Assessment of Compliance with the EBS Performance Objectives"). There are two Key Technical Uncertainties, identified in Review Plan 5.4, related to thermal loading and its effects on the ability of the EBS to meet performance objectives. First, thermal loading is expected to induce thermomechanical effects in the components of the underground facility (including backfill), the emplacement borehole, and the waste package. The NRC's "Staff Technical Position (STP) on Geologic Repository Operations Area

Underground Facility Design -- Thermal Loads" (Gupta et. al., 1992) offers guidance to DOE on this subject. The second Key Technical Uncertainty is the difficulty in predicting the nature and composition of the environment of the waste package and the EBS over the extended times of required post-closure performance.

Thermal loads, on the underground facility and its components, have a significant potential to put preclosure performance objectives (such as retrievability) at risk. Hence, thermal loads will be taken into account under each specific review plan for the performance objectives at risk and in Review Plan 4.4 ("Assessment of Compliance with Design Criteria for the GROA Underground Facility"). Coordination with Review Plan 4.4 is necessary to ensure that underground facility design decisions with respect to postclosure performance objectives (the subject of Review Plan 5.3) do not preclude meeting preclosure performance objectives, and vice versa.

Selection of a Type 3 review for this Review Plan is based on the following assumptions:

- (1) The postclosure features of the underground facility will be designed by DOE in accordance with either the design-related descriptions given in Sections 6.2.6 and 6.2.7 of the Site Characterization Plan (DOE, 1988), or the alternative design concept introduced at the Nuclear Waste Technical Review Board (NWTRB) meeting (Stahl, 1992) at which DOE proposed a method for demonstrating compliance with this regulatory topic. Although the design presented to the NWTRB differs significantly from designs described in the SCP (horizontal drift emplacement vs. vertical or horizontal borehole emplacement), the review strategy would be the same for any of these designs.
- (2) The postclosure design features of the underground facility will be described and incorporated into DOE's performance assessments for both the EBS performance objectives of containment and isolation, as given in 10 CFR 60.113, as well as the overall system performance objective, as given in 10 CFR 60.112.
- (3) Compliance with preclosure aspects of 10 CFR 60.133(a)(1), 60.133(e)(2), 60.133(f) and 60.133(i) will be assessed under Review Plan 4.4.

Based on current knowledge, no Key Technical Uncertainties have been identified under this Review Plan and, thus, the risk of noncompliance with the Engineered Barrier System performance objectives and the overall system performance objective is presently assessed to be nil. However, Key Technical Uncertainties may yet arise as a direct result of research and site studies. If and when Key Technical Uncertainties pertinent to this review plan are identified, the strategy for this review plan will be re-assessed.

## **REVIEW STRATEGY:**

### **Acceptance Review (Type 1):**

In conducting the acceptance review of the assessment of compliance with the design criteria for the postclosure features of the underground facility, the reviewer should determine if the information present in the license application and its references for determining compliance with the applicable regulatory requirements is complete in technical breadth and depth as identified in the FCRG. The reviewer should determine that all appropriate information necessary for the staff to review the demonstration of compliance with the design criteria for the postclosure features of the underground facility is presented such that the assessments required by the regulatory requirements associated with total system and subsystem performance objectives or other technical criteria can be performed.

The reviewer should determine that the information in the license application is presented in such a manner that the assumptions, data, and logic leading to a demonstration of compliance with the requirement are clear and do not require the reviewer to conduct extensive analyses or literature searches. The reviewer should also determine that controversial information and appropriate alternative interpretations and models have been acceptably described and considered.

Finally, the reviewer should determine if DOE has either resolved all the NRC staff objections that apply to this requirement or provided all the information requested in Section 1.6.2 of the FCRG, for unresolved objections. The reviewer shall evaluate the effects of any unresolved objections, both individually and in combination with others, on: (1) the reviewer's ability to conduct a meaningful and timely review; and (2) the Commission's ability to make a decision regarding construction authorization within the three-year statutory period.

### **Safety Review (Type 3):**

This regulatory requirement topic is limited to assessment of compliance with the design criteria for the postclosure features of the underground facility from the postclosure perspective of EBS performance. It is not concerned with preclosure considerations of assessment of compliance with the design criteria for the GROA Underground Facility. Preclosure considerations will be covered under another review plan (Review Plan 4.4 - "Assessment of Compliance with the Design Criteria for the GROA Underground Facility").

The reviewer's objectives are as follows:

- (1) Understand and evaluate DOE's compliance demonstration logic.
- (2) Conduct a preliminary review of the data base used for compliance demonstration to determine which parts of the data are most uncertain or that may be incomplete.
- (3) Determine whether portions of the data and/or analyses submitted shall be subjected to further detailed review (in addition to those areas requiring detailed Safety Reviews which may arise in the future.
- (4) Determine whether any use of expert opinion (in lieu of experiments or analyses) was

appropriate.

Examples of specific review activities that will be required of the staff following receipt of DOE's license application include (1) confirmation that DOE has fully included the most recent information in the required compliance demonstrations and (2) confirmation that DOE's compliance demonstrations include, either in this part of the license application or by reference elsewhere in the application, compliance demonstrations identified in Section 5.3 of the FCRG.

Prior to the NRC review, the DOE's analysis will be evaluated to determine if the basic assumptions contained in the type selection rationale have been met. These assumptions are given below for compliance with the design criteria for the postclosure features of the underground facility:

- (1) The postclosure features of the underground facility will be designed by DOE in accordance with either the design-related descriptions given in Sections 6.2.6 and 6.2.7 of the Site Characterization Plan (DOE, 1988), or the alternative design concept introduced at the Nuclear Waste Technical Review Board (NWTRB) meeting (Stahl, 1992) at which DOE proposed a method for demonstrating compliance with this regulatory topic. Although the design presented to the NWTRB differs significantly from designs described in the SCP (horizontal drift emplacement vs. vertical or horizontal borehole emplacement), the review strategy would be the same for any of these designs.
- (2) The postclosure design features of the underground facility will be described and incorporated into DOE's performance assessments for both the EBS performance objectives of containment and isolation, as given in 10 CFR 60.113, as well as the overall system performance objective, as given in 10 CFR 60.112.
- (3) Compliance with preclosure aspects of 10 CFR 60.133(a)(1), 60.133(e)(2), 60.133(f) and 60.133(i) will be assessed under Review Plan 4.4.

If the above assumptions are met, the staff review will follow the strategy described here. If these assumptions are not met, the staff review may require a different strategy for evaluating DOE's demonstration of compliance with the applicable regulatory requirements. It is expected, however, that any deviation from these assumptions will be known well in advance of the time of license application submittal, and this strategy shall be revised in accordance with such new information as it becomes available to the staff.

In conducting the Safety Review, the reviewer shall determine if the information presented in the license application and its references is an acceptable demonstration of compliance with all applicable regulatory requirements. At a minimum, the reviewer shall determine the adequacy of the data and analyses that are presented in the license application as DOE's supporting information concerning its demonstration of compliance with this regulatory requirement topic.

The specific aspects, of the license application, on which the reviewer will focus are described and the acceptance criteria are identified in Section 3.0 of this review plan. Specifically, DOE will be required

to demonstrate that its design for the underground facility meets those additional design criteria specified in 10 CFR 60.133 that are applicable for the postclosure period. The review shall include consideration of the design that has been presented and of the effects of that design on postclosure performance. The scope of the review shall include backfill, if used, since backfill is a component of the postclosure (EBS) features of the underground facility. Pertinent design criteria chosen by DOE shall also be reviewed for adequacy. The reviewer shall determine whether or not DOE has demonstrated that the design bases for the postclosure features of the underground facility take into account the results of DOE's site characterization activities.

The design bases for the postclosure features of the underground facility shall be reviewed to ascertain their adequacy and to ensure that compliance with postclosure performance objectives can be satisfactorily determined on the basis of the information presented in the application. The reviewer shall evaluate DOE's description of how the postclosure features of the underground facility contribute as a barrier for radionuclide isolation. Models used by the DOE to predict postclosure behavior of the underground facility (including backfill) shall be reviewed for completeness and adequacy. Descriptions of the models should include:

- (1) identification and evaluation of design parameters used to meet design criteria.
- (2) description of uncertainties in parameters and of how these uncertainties are reflected in models.
- (3) descriptions of analyses and models used to predict future conditions and changes in postclosure features of the underground facility model parameters.
- (4) description of uncertainties in analytical models and how such uncertainties affect predicted results.
- (5) results that are used to support analyses and models of behavior that are based upon the postclosure features of the underground facility: field tests, in-situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies .

For supporting information described in Item (5), the following shall be reviewed for completeness and adequacy:

- (a) variability and uncertainty of data and resultant propagation of errors in models or analyses for which such data was used.
- (b) discussions of data representativeness, including uncertainties associated with extrapolation of data.
- (c) documentation and validation of models and analyses.
- (d) identification of, and justification for, assumptions used in analyses and models.
- (e) input and output data and interpretations of the data with the basis for interpretation.
- (f) the role of expert judgment, if used, in models and analyses.

The Safety Review shall establish whether or not DOE's assessment shows that all anticipated processes and events have been considered and analyzed. For disposal in the saturated zone, the Safety Review shall also determine whether or not DOE's assessment shows that both the partial and complete filling with groundwater of available void space in the postclosure features of the underground facility have been considered and analyzed.

In order to conduct an effective review, the reviewer shall rely on various sources ( e.g. staff expertise and independently acquired knowledge, information, and data such as the results of research activities being conducted by the NRC's Office of Nuclear Regulatory Research). These sources are to supplement the information provided by the DOE in its license application. The reviewer shall also have available specific pertinent documents that were commissioned by the NRC, DOE, or others. These documents should be acquired, in advance of the review, by the staff reviewer in anticipation of the license application submittal. Examples of such documents include Sadeghi et al., 1990; Wilson, 1991; Manaktala and Interrante, 1990; and Wu et al., 1991.

With respect to thermal loads, the reviewer shall assess how DOE has applied the methodology described in the "Staff Technical Position on Geologic Repository Operations Area Underground Facility Design - Thermal Loads" (Gupta et. al., 1992). This Staff Technical Position offers guidance to the DOE on development of appropriately coupled models, in an iterative approach, to account for the thermal, mechanical, hydrological, and chemical processes that are induced by repository-generated thermal loads.

The reviewer shall also use any additional data and knowledge that can refine the assessment of compliance with the design criteria for the postclosure features of the underground facility, and shall perform, as necessary, additional analyses to confirm the resolution capabilities of the methodologies. It is incumbent upon the reviewer to have acquired a body of knowledge regarding these and other critical considerations in anticipation of conducting the review, so as to ensure that the assessment of compliance with the design criteria for the postclosure features of the underground facility is sufficient, in scope and depth, to provide the information required to resolve the concerns.

At the reviewer's discretion, independent analyses of results of DOE's models or analyses may be performed, using data, descriptions, and models provided by DOE. Alternatively, when deemed appropriate, simple confirmatory calculations may be performed using appropriate procedures. Finally, a brief site visit may be required for the staff to verify that data and parameters used in DOE's analyses accurately reflect the conditions at the site.

To conduct a successful Safety Review of the assessment of compliance with the design criteria for the postclosure features of the underground facility, the reviewer may be required to use additional information provided in other sections of the license application. The information in this section of the license application will be cross-referenced to information and analyses submitted for the following review plans:

- o Review Plan No. 3.1.5 -- Description of Individual Systems and Characteristics of the Site -- Integrated Natural Response to the Maximum Design Thermal Load
- o Review Plan No. 4.1.3 -- Description of the GROA Structures, Systems, and Components: Underground Facilities
- o Review Plan No. 4.4 -- Assessment of Compliance with Design Criteria for the GROA Underground Facility

- o Review Plan No. 5.1 -- Description of Engineered Systems and Components that provide a Barrier between the Waste and the Geologic Setting
- o Review Plan No. 5.2 -- Assessment of Compliance with the Design Criteria for the Waste Package and its Components
- o Review Plan No. 5.4 -- Assessment of Compliance with the Engineered Barrier System Performance Objectives
- o Review Plan No. 6.1 -- Assessment of Compliance with the Requirement for Cumulative Releases of Radioactive Materials
- o Review Plan No. 6.2 -- Assessment of Compliance with the Individual Protection Requirements
- o Review Plan No. 6.3 -- Assessment of Compliance with the Groundwater Protection Requirements
- o Any other review plans that contain pertinent information.

Section 5.3 of the License Application Review Plan evaluates analyses and information that will be used to review other sections of the license application, so as to determine compliance with the related design and performance requirements that apply to the GROA. The staff finding on the analyses for Section 5.3 shall be based not only on the evaluation described in this review plan, but also on the staff findings on the other review plans listed above.

**RATIONALE FOR REVIEW STRATEGY (OPTIONAL):**

Not applicable.

**Contributing Analysts:**

CNWRA: Emil Tschoepe, John Walton, Mikko Ahola.

NRC: David Dancer, S-J Chern, Robert Carlson.

**Date of Analysis:** February 12, 1993

**APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:**

**Type 1:**

- 10 CFR 60.21(c)(1)(ii)(D)
- 10 CFR 60.21(c)(1)(ii)(E)
- 10 CFR 60.21(c)(1)(ii)(F)

10 CFR 60.21(c)(2)  
10 CFR 60.21(c)(3)  
10 CFR 60.21(c)(6)  
10 CFR 60.21(c)(14)  
10 CFR 60.133(a)(1)  
10 CFR 60.133(e)(2)  
10 CFR 60.133(f)  
10 CFR 60.133(h)  
10 CFR 60.133(i)

**Type 3:**

10 CFR 60.133(a)(1)  
10 CFR 60.133(e)(2)  
10 CFR 60.133(f)  
10 CFR 60.133(h)  
10 CFR 60.133(i)

**REFERENCES:**

U.S. Department of Energy, "Chapter 6.2, Current Repository Description" in *Site Characterization Plan: Yucca Mountain Site, Nevada Research and Development Area, Nevada*, Washington, DC: Office of Civilian Radioactive Waste Management, Vol. III, Part A, DOE/RW-0199, December 1988.

Manaktala, H.K. and C.G. Interrante, *Technical Considerations for Evaluating Substantially Complete Containment of High-Level Waste Within the Waste Package*, Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, NUREG/CR-5638, December 1990.

Gupta, D., J. Peshel, and J. Bunting, *Staff Technical Position on Geologic Repository Operations Area Underground Facility Design -- Thermal Loads*, Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards, NUREG-1466, December 1992.

Sadeghi, M.M., T.H. Pigford, P.L. Chambre, and W.W. Lee, *Prediction of Release Rates for a Potential Waste Repository at Yucca Mountain*, Berkeley, CA: Lawrence Berkeley Laboratory, LBL-27767, October 1990.

Stahl, D., *Source Term Concept and Definition*. Presentation to the Nuclear Waste Technical Review Board Meeting October 14-16, Las Vegas, NV: Waste Package Performance Analysis Management and Operating Contractor, 1992.

Wilson, M.L., *A Simplified Radionuclide Source Term for Total-System Performance Assessment*, Albuquerque, NM, Sandia National Laboratories, SAND91-0155, November 1991.

Wu, Y.T., A.G. Journel, L.R. Abramson, and P.K. Nair, *Uncertainty Evaluation Methods for Waste Package Performance Assessment*, Nuclear Regulatory Commission, Office of Nuclear Regulatory Research, NUREG/CR-5639, January 1991.