PLAN FOR THE TECHNICAL REVIEW OF WASTE PACKAGES CONTAINING MULTI-PURPOSE CANISTERS

Prepared for

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ABSTRACT

This Plan for the Technical Review of Waste Packages Containing Multi-Purpose Canisters (MPCs) describes the NRC's approach to reviewing DOE's MPC design, which is to be incorporated into the high-level radioactive waste (HLW) package design. The plan describes NRC's communication and review activities which will respond to DOE's design detail submittals. The format for such submittals has not been finalized by DOE, although one or more topical reports is currently planned. The Plan also describes how NRC's review activities are related to certain License Application Review Plan (LARP) products within the NRC's Overall Review Strategy (ORS). It is not the intent of the staff to maintain this review plan current. Rather, this review plan will form the basis and establish the priority for developing appropriate sections of the LARP.

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1 INTRODUCTION

The U.S. Department of Energy (DOE), in a major programmatic decision in February 1994, opted to proceed with the design and certification of the multi-purpose canister (MPC) system for handling, transporting, storing, and disposing of spent nuclear fuel assemblies. As a result, the MPC has become part of the program baseline for the Civilian Radioactive Waste Management System (CRWMS). The DOE expects that implementing the MPC approach will facilitate the timely acceptance of spent nuclear fuel from the utilities having nuclear power plants.

To fulfill its expectations on the deployment of the MPC, the DOE has approached the Nuclear Regulatory Commission (NRC) for timely certifications for the transportation and storage casks, and review and guidance on documents relating to disposal. The DOE planned to prepare a Topical Report for submittal to NRC in FY95 on the burn-up credit issues related to high-level radioactive waste (HLW) disposal. Recently, DOE has requested guidance on the format and content of any topical reports which may be developed. It is anticipated that transportation and storage topical reports will be submitted by DOE and reviewed by NRC before review for repository disposal issues can be completed. The DOE has planned several technical exchanges with the NRC during FY94–98 to facilitate early review of technical concerns in the MPC program. The DOE schedule for MPC design and development is ambitious and will require the NRC to provide timely technical reviews of DOE technical products.

The HLW regulations (10 CFR Part 60) focus on an engineered barrier system (EBS) and not on an individual component such as an MPC with an overpack designed for use in waste disposal. This plan has two purposes. First, it provides initial guidance to the staff for reviewing the technical documents which the DOE may provide concerning the MPC design. Second, it provides a road map to the staff on the regulatory guidance which must be developed and implemented in NUREG-1323, the License Application Review Plan (LARP) for a Geologic Repository for Spent Fuel and High-Level Radioactive Waste. It is not the intent of the staff to maintain this plan current. Rather, this plan will form the basis and establish the priorities in the development of the LARP.

The focus of this Plan is to review those aspects of the MPC program that relate to the disposal of the spent nuclear fuel. As such, the approach is to maximize use of regulatory products and ongoing development of the systematic regulatory analysis (SRA) of 10 CFR Part 60. This plan is developed under the Overall Review Strategy (ORS) for the HLW disposal program (Johnson, 1993). This plan draws primarily upon the LARP and the format and content regulatory guide (FCRG). The ORS provides general guidance and is the umbrella under which the FCRG, LARP, technical exchanges, and topical report reviews are developed. Chapter 2 of this plan describes the relationship among the various regulatory products under the ORS. At present, the various sections of the LARP that apply to the MPC design are in the early stages of development. For the purposes of this document, existing pertinent parts of the ORS, FCRG, and LARP have been abstracted and appropriately modified to satisfy the objectives of this Plan. In doing so, the reader is being provided an overview of many of the disposal issues that need to be addressed at the time of license application (LA). A further step is taken where a partial list of MPC concept-related technical issues are identified. These issues will be analyzed and examined critically after additional interaction with the DOE to ensure a timely address of the pertinent and strategically important issues.

1.1 PURPOSE

The purpose of this plan is to guide the staff in performing a review of the MPC design and to communicate to DOE issues which may obviate the ability of the MPC to acceptably meet long-term disposal performance objectives and design requirements from 10 CFR Part 60. This Plan is intended to be a vehicle by which NRC will facilitate early identification and review of technical concerns in the MPC program. DOE would thus have the opportunity to address and resolve such issues prior to large-scale fabrication of MPCs. The review is also intended to minimize the potential for licensing problems related to the MPC upon review of DOE's application for construction authorization. The plan is intended to facilitate timely technical reviews of schedule-driven DOE technical products. The staff's review of topical report(s) or other technical documents on MPC concerns should thus prepare the staff to conduct a Safety Evaluation detailing the review of such concerns with the MPC concept. Technical exchanges are expected to provide a means by which NRC can identify technical concerns and DOE can describe their plans for resolving those concerns.

1.2 SCOPE

This Plan includes guidance toward conducting technical exchanges with DOE and reviewing topical report(s) or other technical documents which DOE submits concerning MPC issues. It also presents review plans and methodologies (as they currently exist) which NRC will use in reviewing the DOE LA, and pertinent pre-LA submittals, to construct a geologic repository for disposal of HLW.

The Plan for the Technical Review of Waste Packages Containing MPCs should facilitate communication with DOE concerning issues which may obviate the utility of the MPC for disposal at a geologic repository. This communication is needed for use in MPC design prior to large-scale fabrication of MPCs. At the same time, the Plan should prepare the staff for a broad-based, pre-licensing regulatory review of the MPC design for Yucca Mountain. This includes a preliminary performance assessment (PA) review to the extent limited by current site characterization data, and waste package (WP) and repository design information to develop information about the acceptability of the MPC design. As a result of NRC's reviews, certain portions of particular Compliance Determination Methods (CDMs) will be developed in detail, contributing to timely review of the License Application for Construction and pertinent pre-LA submittals in the future.

The Plan scope includes identification of limitations of the review (based on DOE preliminary site characterization data, and WP and repository design information). Issues within the scope of this review include those related to burn-up credit and criticality control, including identification of conditions that may have potentially adverse effects on the WP and repository performance. These include DOE design concepts and details related to storage and transportation requirements which also may have repository design and performance implications. This review will not be directed toward storage and transportation aspects of the MPC. However, interaction with NRC NMSS staff responsible for storage and transportation licensing aspects is necessary to exchange information on the subject and ensure completeness of the staff's review for acceptability of an MPC design.

Technical concerns related to the MPC beyond burn-up credit and criticality control are identified in this plan, and DOE may choose to resolve those concerns by means other than topical reports. If so, DOE's plan for such resolution should be reviewed, along with progress on resolution activities. It is expected that some issues will require earlier attention than others, as some are unique to

the MPC design and others will be deferred to later resolution. Those requiring earlier attention would be expected to be resolved prior to mass production of MPCs. Deferred WP issues are those for which final disposal overpacks, EBS, and repository designs might be relied upon by DOE to meet performance objectives and design requirements for which compliance is not demonstrated during the pre-licensing stage. Resolution of deferred WP issues should be scheduled for completion prior to submittal of the License Application for Construction of the geologic repository.

1.3 REFERENCE

Johnson, R.L. 1993. Overall Review Strategy for the Nuclear Regulatory Commission's High-Level Waste Repository Program. Nuclear Regulatory Commission, Office of Nuclear Material Safety and Safeguards. Washington, DC 20555.

2 OVERALL REVIEW STRATEGY

The NRC ORS defines pre-LA review objectives and strategies by which the staff is directed to accomplish them. The seven strategies ORS uses in its pre-LA reviews are as follows:

(i) Conduct reviews consistent with the general phases and schedule of the DOE program

(ii) Use a systematic, audit approach and focus technical reviews on supporting the pre-LA review objectives

(iii) Conduct focused quality assurance (QA) reviews and QA audits

(iv) Conduct reviews of DOE's issue resolution strategy and performance allocation process

(v) Conduct reviews of DOE's Annotated Outline (AO) for the LA and make preliminary sufficiency/acceptance findings

(vi) Support reviews by documenting concerns as open items and tracking DOE resolution of these open items, using a computer data base

(vii) Support reviews with open interactions with DOE and other parties, together with considering concerns of other parties

In keeping with the objectives of the ORS and the associated implementation strategies, the Plan for the Technical Review of Waste Packages Containing MPCs is developed to reflect all those aspects of a technical program that can be addressed with the state of information available on the MPC design at present. An integrated approach has been adopted for this plan, whereby this Plan is consistent with the ORS. This Plan complements the LARP by input to CDMs on WP design (CDM 5.2) and EBS performance objectives (CDM 5.4). The ORS indicates that a topical report review plan is a product which is part of the ORS, as are the LARP, study plan review plans, SCP progress report review plans, and iterative performance assessment reports. The ORS also categorizes topical report reviews as an applicable pre-LA review and supporting activity for a Type 3 LA review.

DOE is also planning to conduct several technical exchanges with the NRC to update and present progress on the MPC development activities. Technical exchanges and technical analyses using available methods fall into the category of applicable pre-LA review and supporting activities which support a Type 4 LA review. As an example, the Key Technical Uncertainty (KTU) on WP criticality, which is closely related to the subject of Burnup Credit for MPCs for disposal, has been defined in review plans 5.2 and 5.4 as requiring Type 4 review.

DOE has indicated that it plans to submit topical reports to the NRC on the subject of burn-up credit for the MPC. If DOE chooses to address this or other technical issues in one or more topical reports, the reviewer should follow the general guidance provided in NRC's Topical Report Review Plan.

3 APPLICABLE REGULATORY GUIDES

3.1 APPLICABLE SECTIONS FROM THE FORMAT AND CONTENT REGULATORY GUIDE

The format and content of the information DOE provides for the NRC staff to review the LA to construct a geologic repository for disposal of HLW are given in the FCRG. Concerning the application of an MPC, which is ultimately expected to become part of a disposal package, portions of three individual sections of the FCRG are directly pertinent. They are sections 5.1, "Description of Engineered Systems and Components That Provide a Barrier Between the High-Level Waste and the Geologic Setting," 5.2, "Assessment of Compliance with the Design Criteria for the Waste Package and Its Components," and 5.4, "Assessment of Engineered Barrier System Compliance with the Performance Objectives." Excerpts from these FCRG sections are included in the Appendix to this plan, so that the reviewer can become familiar with the information that will be required in the LA.

MPC design and performance evaluation will require information that is requested in sections of the FCRG other than 5.1, 5.2, and 5.4. A preliminary assessment indicates that information from the following sections of the FCRG may be needed.

2.5 — Radioactive Material Description
3.1.1 — Geologic System
3.1.2 — Hydrologic System
3.1.3 — Geochemical System
3.1.5 — Integrated Natural System Response to the Maximum Design Thermal Loading
4.1 — Description of the GROA Structures, Systems, and Components
4.1.1 — Surface Facilities
4.1.2 — Shafts and Ramps
4.1.3 — Underground Facility
4.1.4 — Radiation Protection Systems
4.1.5 — Interfaces between Structures, Systems, and Components
5.3 — Assessment of Compliance with the Design Criteria for the Post-Closure Features of the Underground Facility
6.1 — Assessment of Compliance with the Requirement for Cumulative Releases of Radioactive Materials
8.3 — Performance Confirmation Program for the Engineered Barrier System

3.2 OTHER APPLICABLE REGULATORY GUIDES

Listed below are regulatory guides that provide additional guidance.

- "Validation of Calculational Methods for Nuclear Criticality Safety," Nuclear Regulatory Commission, Regulatory Guide 3.41, Revision 1, May 1977.

- "Criticality Safety for Handling, Storing, and Transporting LWR Fuel at Fuels and Materials Facilities," Nuclear Regulatory Commission, Regulatory Guide 3.58, October 1986.

4 APPLICABLE REVIEW PLANS FROM THE LICENSE APPLICATION REVIEW PLAN

The strategy and methods by which the NRC staff will review the LA to construct a geologic repository for disposal of HLW are given in the LARP. Concerning the application of an MPC, which is ultimately expected to become part of a disposal package, three individual review plans will be directly affected:

(i) Review Plan 5.1, "Description of Engineered Systems and Components That Provide a Barrier between the Waste and the Geologic Setting"

(ii) Review Plan 5.2, "Assessment of Compliance with the Design Criteria for the Waste Package and its Components"

(iii) Review Plan 5.4, "Assessment of Engineered Barrier System Compliance with the Performance Objectives"

As part of Plan, it is expected that the CDMs for each of these three individual review plans will be developed as detailed MPC design information from DOE becomes available.

Review Plan 5.3, "Assessment of Compliance with the Design Criteria for the Post-Closure Features of the Underground Facility," is also important with respect to development of the MPC. The underground facility is a part of the EBS, as is the waste package. Both the underground facility and the waste package contribute to meeting the EBS performance objective of gradual release expressed in 10 CFR 60.113(a)(1)(i)(B) and 60.113(a)(1)(ii)(B). The EBS containment performance objective expressed in 10 CFR 60.113(a)(1)(i)(A) and 60.113(a)(1)(ii)(A) is to be met by containing radionuclides within the waste packages. The functions of the underground facility with respect to containment may thus extend to control of the waste package environment. The Plan for the Technical Review of Waste Packages Containing MPCs does not focus on Review Plan 5.3 for the following reasons: (1) the Plan is expected to be useful for a relatively short period (2-3 years) which extends up to the time at which MPCs will be fabricated; (2) underground facility design for postclosure is not expected to be significantly developed during that period; and (3) the features of the underground facility design are not expected to substantially impact MPC design, at least not to the extent that waste package design impacts MPC design. It should be noted, however, that the underground facility design can play an important role in waste package performance by maintaining the waste package environment within intended design parameters. During development of CDMs 5.1, 5.2, and 5.4 considering the MPC concept, interfaces that relate to the CDM 5.3 will be identified. As a result, important issues affecting the waste package design will be considered and incorporated into CDM 5.2.

In this section are excerpts from the LARP as it has currently been developed. Although CDMs for Review Plans 5.2 and 5.4 have not yet been generated, technical issues related to the MPC have been listed for each of those review plans for informational purposes. Also for Review Plans 5.2 and 5.4, tables are included in sections 4.2.4.3 and 4.3.4.3, respectively, identifying interfaces to other review plans from which information is required for compliance determination. As the Plan for the Technical Review of Waste Packages Containing MPCs is implemented, it is expected that these CDMs and their associated CDSs would be developed more completely to reflect consideration of the MPC and results of this plan. Those portions of review plans which have not been developed are indicated by the notation TBD.

Technical issues have been broadly identified for Review Plans 5.2 and 5.4, which deal with WP design criteria and EBS performance, respectively. For informational purposes, these issues are listed in the Sections 4.2.3.2 and 4.3.3.2 of those review plans.

4.1 REVIEW PLAN 5.1—DESCRIPTION OF ENGINEERED SYSTEMS AND COMPONENTS THAT PROVIDE A BARRIER BETWEEN THE WASTE AND THE GEOLOGIC SETTING

4.1.1 Applicable Regulatory Requirements

For this review plan, the staff will determine if the following regulatory requirements on the description and discussion of the engineered systems and components that form a barrier between the waste and the geologic setting, defined in 10 CFR 60.21(c), as applicable, are met.

§ 60.21(c)(2)(i)-(iv)
§ 60.21(c)(6)
§ 60.21(c)(14)

4.1.2 Review Strategy

4.1.2.1 Acceptance Review

To determine whether this section of the DOE's LA is acceptable for docketing, the staff will determine whether the information submitted is consistent with that identified in the corresponding section of the Regulatory Guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG).

Before the receipt of the license application, the staff will have conducted pre-licensing reviews of DOE's program, including technical reviews and quality assurance reviews and audits. The staff will have documented its concerns, resulting from these pre-license application reviews, as open items. Some of these open items, referred to as objections to LA submittal, may be critical to the staff's license application review, because lack of acceptable DOE resolution would prevent NRC from conducting a meaningful review. Therefore, as part of its Acceptance Review for docketing, the staff will evaluate how significant any unresolved objection to license application submittal is, to the effective conduct of licensing activities, using the criteria given in Section 3.1 of this review plan.

The description of the engineered systems and components in Section 5.1 of the license application will provide the basis for the detailed Compliance Reviews of the information provided in the following sections of the license application:

License Application Section	Title
5.2	Assessment of Compliance with the Design Criteria for the Waste Package and its Components

5.3 Assessment of Compliance with the Post-Closure Features of the Design Criteria for the Post-Closure Features of the Underground Facility

5.4 Assessment of Compliance with the Engineered Barrier System Performance Objectives

5.5 Radiation Protection

Thus, information contained in Section 5.1 will be reviewed in parallel with the information contained in Sections 5.2, 5.3, 5.4, and 5.5. Therefore, the reviewer should determine that all appropriate descriptive information necessary for the staff to conduct a Compliance Review of the Engineered Barrier Systems is present in Section 5.1 of the license application.

If it is determined that the descriptive information in Section 5.1 of the license application is inadequate to support any of the Compliance Reviews called for in Sections 5.2, 5.3, 5.4, and 5.5, then additional information will be requested from DOE before the Compliance Reviews of the sections in question can continue.

4.1.2.2 Compliance Review

Safety Review

As noted above, most of the descriptive material provided in this section of the license application will be initially reviewed and then evaluated as part of the Compliance Review of those sections of the license application which use this information. Section 4.2 ("Interfaces") of this review plan describes where the Compliance Review(s) of the information in this section of the license application will take place.

For each of the Compliance Reviews described in Section 4.2, a portion of the review will therefore focus on whether the descriptive information provides an acceptable basis for the associated assessment. Thus, this portion of the review will result in an Evaluation Finding for the specific supporting information in that section of the license application in which it is being used.

Therefore, under this review plan, no additional Compliance Review will be done; the staff will make only an "aggregate" Evaluation Finding for the whole description of the EBS. Such a finding would collectively reflect the sum of the specific Evaluation Findings made in those sections of the license application described in Section 4.2.

4.1.3 Review Procedures and Acceptance Criteria

4.1.3.1 Acceptance Review

In conducting the Acceptance Review for docketing, the staff will compare information in the LA concerning the engineered systems and components that provide a barrier between the waste and the geologic setting with the corresponding section of the FCRG and with the staff's resolution status of

objections in the Open Item Tracking System and determine if this information meets the following criteria.

(i) The information presented in the LA is clear, is completely documented consistent with the level of detail presented in the corresponding section of the FCRG, and the references have been provided.

(ii) DOE has either resolved, at the staff level, the NRC objections to LA submittal that apply to this regulatory requirement topic or provided all information requested in Section 1.6 of the FCRG for unresolved objections, namely, DOE has:

- Identified all unresolved objections
- Explained the differences between NRC and DOE positions that have precluded resolution of each objection
- Described attempts to achieve resolution
- Explained why resolution has not been achieved
- Described the effects of the different positions on demonstrating compliance with 10 CFR Part 60

(iii) In addition, unresolved objections, individually or in combination with others, will not prevent the reviewer from conducting a meaningful Compliance Review and the Commission from making a decision regarding construction authorization within the three-year statutory period.

4.1.3.2 Compliance Reviews

The compliance determinations undertaken by NRC staff will consider whether the Acceptance Criteria specified for each of the following Compliance Reviews have been met. The results of the compliance determinations shall be documented in the staff's Safety Evaluation Report (SER) to provide the basis for the actual Evaluation Findings.

Safety Review of 10 CFR 60.21(c)

The staff's Compliance Review will consist of the following two steps. First, the staff will review the descriptive information provided for the engineered systems and components that provide a barrier between the waste and the geologic setting. This will provide an overall understanding of how DOE has presented its information on the many individual aspects of the engineered systems and components that provide a barrier between the waste and the geologic setting and how this information has been integrated. The types of descriptive information to be provided to other review plans are listed in Section 4.2.2.

Second, after the staff has conducted each of the Compliance Reviews for those sections of the LA identified in Section 4.2.2, the individual Evaluation Findings from these reviews will be considered on balance to determine whether the following Acceptance Criterion has been met:

(1) The descriptive information for the engineered systems and components that provide a barrier between the waste and the geologic setting provides an acceptable basis for all of the associated assessments that rely on this information

4.1.4 Implementation

4.1.4.1 Review Responsibilities

The review responsibilities for this review plan are as follows:

Lead:	NMSS-DWM-ENG
Support:	NMSS-DWM-PAHB

4.1.4.2 Interfaces

Input Information

Input Information	Review Plan No.
Evaluation Findings	2.5 - Radioactive Material
Evaluation Findings	5.2 - Assessment of Compliance with the Design Criteria for the Waste Package and Its Components
Evaluation Findings	5.3 - Assessment of Compliance with the Design Criteria for the Post-Closure Features of the Underground Facility
Evaluation Findings	5.4 - Assessment of Engineered Barrier System Compliance with the Performance Objectives
Evaluation Findings	8.3 - Performance Confirmation Program for the Engineered Barrier System

Output Information

Output from activities associated with this review plan will provide specific information important for use in other review plans as the following table indicates. For further detail, see FCRG Sections 5.1 through 5.1.5.

Output Information	Review Plan No.
A description of the kind, amount, and specifications of the radioactive material proposed to be incorporated into waste packages.	2.5 - Radioactive Material

Output Information	Review Plan No.
Description of the waste package design and alternative designs, including the waste form; containers; shielding; packing; absorbent materials immediately surrounding an individual waste container; coatings; liners; structural supports; fillers; materials specifications; and manufacturing methods.	5.2 - Assessment of Compliance with the Design Criteria for the Waste Package and its Components
Description of the design of the underground facility, including (1) the waste emplacement areas, panels, emplacement drifts, and boreholes; (2) backfill materials and their properties; (3) provisions for retrieval; and (4) pre-emplacement site conditions.	5.3 - Assessment of Compliance with the Design Criteria for the Post-Closure Features of the Underground Facility
A description of (1) intended functions, including any assigned performance allocation, of each component of the EBS; (2) performance assessment codes, including assumptions and supporting research, testing, and model development; and (3) comparative evaluation of the alternative waste package designs.	5.4 - Assessment of Engineered Barrier System Compliance with the Performance Objectives
A discussion of the EBS performance confirmation program, including (1) *in situ* waste package and waste form monitoring; (2) waste package external environment monitoring; (3) laboratory waste package monitoring; and (4) program schedule and duration.	8.3 - Performance Confirmation Program for the Engineered Barrier System

4.1.5 Example Evaluation Findings

The staff should consider the Example Evaluation Findings presented below together with the Acceptance Criteria set forth in Section 3.0 when making the actual Evaluation Findings resulting from the Acceptance Review for docketing, and the subsequent Compliance Review. The actual Evaluation Findings resulting from the Compliance Reviews, and the supporting basis, should be documented in the staff's SER.

4.1.5.1 Finding for Acceptance Review

The NRC staff finds the information presented by DOE, as defined by the applicable 10 CFR Part 60 Regulatory Requirements, is acceptable (not acceptable) for docketing and a subsequent Compliance Review.

4.1.5.2 Findings for Compliance Reviews

Finding for 10 CFR 60.21(c)

The NRC staff finds the information for descriptions, assessments, and analyses is (is not) adequate, and there is (is not) reasonable assurance the applicable regulatory requirements of 10 CFR

60.21(c), listed in Section 1.0 of this Review Plan, will be met for the engineered systems and components that provide a barrier between the waste and the geologic setting.

4.1.6 References

Nuclear Regulatory Commission, "Format and Content for the License Application for the High-Level Waste Repository," Office of Nuclear Regulatory Research. [Refer to the "Products List" for the Division of High-Level Waste Management, to identify the most current edition of the FCRG in effect.]

4.2 REVIEW PLAN 5.2—ASSESSMENT OF COMPLIANCE WITH THE DESIGN CRITERIA FOR THE WASTE PACKAGE AND ITS COMPONENTS

4.2.1 Applicable Regulatory Requirements

The subject of this review plan is an assessment of compliance with the design criteria for the WP and its components called for in 10 CFR 60.21(c), as applicable:

§ 60.21(c)(1)(ii)(A)
§ 60.21(c)(1)(ii)(D)
§ 60.21(c)(1)(ii)(E)
§ 60.21(c)(1)(ii)(F)
§ 60.21(c)(2)(i)-(iv)
§ 60.21(c)(3)(i)-(ii)
§ 60.21(c)(6)
§ 60.21(c)(14)

For this review plan, the staff will determine if the DOE has demonstrated that the WP and its components have been designed in accordance with the design criteria defined by the following regulatory requirements in Subpart E of 10 CFR Part 60, as applicable:

§ 60.131(b)(1)
§ 60.131(b)(7)

§ 60.135(a)(1)-(2)
§ 60.135(b)(1)-(4)
§ 60.135(c)(1)-(3)
§ 60.135(d)

4.2.2 Review Strategy

4.2.2.1 Acceptance Review

To determine whether this section of the DOE's license application is acceptable for docketing, the staff will determine whether the information submitted is consistent with that identified in the

corresponding section of the Regulatory Guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG).

Before the receipt of the license application, the staff will have conducted pre-licensing reviews of DOE's program, including technical reviews and quality assurance reviews and audits. The staff will have documented its concerns, resulting from these pre-license application reviews, as open items. Some of these open items, referred to as objections to license application submittal, may be critical to the staff's license application review, because lack of acceptable DOE resolution would prevent NRC from conducting a meaningful review. Therefore, as part of its Acceptance Review for docketing, the staff will evaluate how significant any unresolved objection to license application submittal is, to the effective conduct of licensing activities, using the criteria given in Section 3.1 of this review plan.

The descriptions provided in Section 5.1 ("Description of the Engineered Systems and Components That Provide a Barrier between the Waste and the Geologic Setting") of the license application will form the basis for the Compliance Review of the information contained in Section 5.2 of the license application. Thus, the review of the information contained in Section 5.1 will be performed in parallel with the review of the information contained in Section 5.2. Therefore, during the Acceptance Review of Section 5.2, the reviewer should determine whether all appropriate WP information necessary for the staff to conduct a Compliance Review of the design has been provided, as described in Section 5.1, and that the information is both internally consistent, and consistent from section-to-section.

4.2.2.2 Compliance Review

Safety Review

This regulatory requirement topic is limited to assessment of compliance of the WP (and its components) with the pertinent 10 CFR Part 60 design criteria. It is not concerned with assessment of compliance of the EBS (exclusive of the WP and its components), with other pertinent 10 CFR Part 60 design criteria and performance objectives. The review of the EBS, from the post-closure perspective, is the subject of the review called for in Section 5.3 ("Assessment of Compliance with the Design Criteria for the Engineered Barrier System") of the license application and its attendant review plan. Finally, the confirmation of the WP design described by DOE in this section of the license application will be the subject of a performance confirmation program described in Section 8.3 ("Performance Confirmation Program for the Engineered Barrier System") of the license application and its attendant review plan.

In general, the reviewer should assess the adequacy demonstration of compliance with the WP design criteria. The specific aspects of the license application on which the reviewer will focus are discussed, and the Acceptance Criteria are identified in Section 3.0 of this Review Plan.

The reviewer's objectives during the Safety Review of this regulatory requirement topic are the following.

(i) Understand and evaluate DOE's compliance demonstration logic

(ii) Conduct a preliminary review of the data base used for demonstrating compliance with the applicable regulatory requirements, to determine which parts of the data are most uncertain or may be incomplete

(iii) Determine whether portions of the data and/or analyses submitted should be subjected to further detailed review (in addition to those areas requiring detailed Safety Reviews that may arise in the future)

(iv) Determine whether any use of expert opinion was appropriate

In conducting the Safety Review, the reviewer should determine if the information presented in the license application and in its references is an acceptable demonstration of compliance with all applicable regulatory requirements. At a minimum, the reviewer should determine the adequacy of the data and analyses that are presented in the license application as DOE's supporting information, concerning its demonstration that its design for the WP (and its components) meets those design criteria specified in 10 CFR 60.131 and 60.135, as appropriate. The review should include consideration of the information that has been presented for those waste forms specified in Section 2.5 ("Radioactive Material Description") of the license application, for disposal at the geologic repository,[1] and evaluation of the contribution of those waste forms to meeting the post-closure performance objectives. Pertinent design criteria chosen by DOE should also be reviewed for adequacy. The reviewer should determine whether DOE has demonstrated that the design bases for the post-closure features of the WP take into account the results of DOE's site characterization activities.

In conducting the Safety Review, the staff will determine if DOE has submitted the following:

(1) A description and discussion of the WP design, including: (i) the principal design criteria and their relationship to any general performance objectives promulgated by the Commission; (ii) the design bases and the relation of the design bases to the principal design criteria; (iii) information relative to materials of construction (including types, grades, approximate dimensions, methods of fabrication); and (iv) codes and standards that DOE proposes to apply to the design and construction of the WP.

(2) A description and analysis of the design and performance requirements for structures and components of the waste package that are important to safety. This analysis should consider the margins of safety under normal conditions and under conditions that may result from anticipated operational occurrences, including those of natural origin.

(3) An identification and justification for the selection of those variables, conditions, or other items that are determined to be probable subjects of license specifications. Special attention should be given to those items that may significantly influence the final waste package design.

(4) An identification of those structures and components of the waste package that require research and development to confirm the adequacy of design. For structures and components important to safety and for the engineered barriers important to waste isolation, DOE should provide a detailed description of the programs designed to resolve safety questions, including a schedule indicating when these questions would be resolved.

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[1] Spent nuclear fuel and high-level radioactive waste are the predominant waste forms expected for disposal, although other waste forms, such as low-level, greater-than-class-C, or transuranic radioactive wastes, might possibly be disposed of at the geologic repository.

In reviewing Items (1) to (4), above, the staff will confirm that DOE has included the following:

(1) An assessment evaluating the effectiveness of engineered and natural barriers,including barriers that may not be themselves a part of the geological repository operations area (GROA), against the release of radioactive material to the environment. The analysis should also include a comparative evaluation of alternatives to the major design features that are important to waste isolation, with particular attention to the alternatives that would provide longer radionuclide containment and isolation.

(2) An analysis of the performance of the major design structures and components, to identify those that are important to safety. For the purposes of this analysis, it should be assumed that operations at the GROA will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the license application.

(3) An explanation of measures used to support the models used to perform the assessments required in Items (1) to (3) above. Analyses and models that will be used to predict future conditions and changes should be supported by using an appropriate combination of such methods as field tests, *in-situ* tests, laboratory tests representative of field conditions, monitoring data, and natural analog studies.

For the information described in Item (3), the following should be reviewed for completeness and adequacy.

(i) Variability and uncertainty of data and resultant propagation of errors in models or analyses for which such data were used

(ii) Discussions of data representativeness, including uncertainties associated with extrapolation of data

(iii) Documentation and validation of models and analyses

(iv) Identification of, and justification for, assumptions used in models and analyses

(v) Input and output data and interpretations of the data, with the basis for interpretation

(vi) The role of expert judgment, if used, in models and analyses

Models and analyses used by the DOE to predict post-closure behavior of the waste package and its components should be reviewed for completeness and adequacy. These analyses should include the following:

(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 models and analyses used to predict future conditions and changes in post-closure features of waste package model parameters

(4) Description of uncertainties in analytical models and how such uncertainties affect predicted results

The Safety Review should establish whether DOE's assessment shows that all anticipated processes and events have been considered and analyzed. For disposal in the saturated zone, the Safety Review should also determine whether DOE's assessment shows that both the partial filling and complete filling, with groundwater, of available void space in the post-closure features of the underground facility, have been considered and analyzed.

To conduct an effective review, the reviewer should 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 NRC's Office of Nuclear Regulatory Research. These sources are to supplement the information provided by the DOE in its license application. The reviewer should also have available specific pertinent documents that were commissioned by NRC, DOE, or others. Specifically, the reviewer will need to: (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 more uncertain or incomplete; (3) determine whether portions of the data and/or analyses submitted should be subjected to further detailed review (in addition to those areas requiring a detailed Safety Review, as specified below); and (4) determine if relevant use of expert opinion was appropriate.

The reviewer should also use any additional data and knowledge that can refine the assessment of compliance with the design criteria for the waste package, and should perform, as necessary, additional analyses to confirm the resolution capabilities of the methodologies. The reviewer should have acquired a body of knowledge regarding these and other critical considerations, in anticipation of conducting the Safety Review, so as to ensure that the assessment of compliance with the design criteria for the post-closure 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.

To conduct an effective Safety Review, the reviewer may choose to refer to additional information and analyses contained in other sections of the license application.

Detailed Safety Review Supported by Analyses

A Detailed Safety Review Supported by Analysis will be needed for evaluation of the KTUs related to the prediction of the following: (1) thermomechanical effects on the waste packages and the EBS; (2) environmental effects on the waste packages and EBS; (3) criticality events in waste packages; (4) the release path parameters (such as size, shape, and distribution of penetrations of waste packages) due to thermomechanical, environmental, or criticality effects; (5) the releases of gaseous radionuclides from waste packages during the containment period and from the EBS during the post-containment period; and (6) the releases of non-gaseous radionuclides from waste packages, during the containment period, and from the EBS, during the post-containment period. These KTUs are the same as those identified in Section 5.4 ("Assessment of Compliance with the Engineered Barrier System Performance Objectives") and the evaluation of these KTUs will be addressed in Section 5.4 of the license application and its attendant Review Plan.

Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations

A Detailed Safety Review, Independent Staff Modeling, and the use of the Results of Staff Investigations will be needed for the KTU related to the extrapolation of short-term laboratory and prototype test results to predict long-term performance of containers and EBS. The evaluation of these KTU will be addressed in Review Plan 5.4 ("Assessment of Compliance with the Engineered Barrier System Performance Objectives") of the license application and its attendant review plan.

However, it should be noted that the design information and analyses submitted in this section of the license application will form the basis for the Compliance Reviews of information contained in Section 5.4 of the license application. Therefore, during the Compliance Reviews of Section 5.2, the reviewer should determine that the appropriate descriptive information, necessary for the staff to conduct the Detailed Safety Reviews, described above, has been provided, and that the information is both internally consistent, and consistent from section-to-section.

4.2.3 Review Procedures and Acceptance Criteria

TBD

4.2.3.1 Acceptance Review

TBD

4.2.3.2 Compliance Reviews

TBD

At the time of development of the Plan for the Technical Review of Waste Packages Containing MPCs, review procedures and acceptance criteria have not been developed. However, certain technical issues have been identified with the MPC design which require early attention and which would be subjects of technical exchanges with DOE. A preliminary list of technical issues that need to be addressed with respect to the MPC and repository disposal has been developed. In particular, the following six issues appear to be most urgent at this time:

- Criticality Control
- Potential Negative Performance Credit versus Zero Performance Credit for MPC
- Preclusion of Design Options (e.g., Thermal Loading)
- Integrity of Internal Constituents (including spent fuel)
- Testing and Verification
- Long-Term Damage to MPC (Materials Degradation, Handling)

It is expected that some issues will require earlier attention than others, as some are unique to the MPC design and others will be deferred to later resolution by DOE. Those requiring earlier attention would be expected to be resolved prior to mass production of MPCs. Section 6 of the Plan for the Technical Review of Waste Packages Containing MPCs describes prelicensing interactions with DOE, such as correspondence and participation in technical exchanges. Deferred waste package issues are those for which final disposal overpacks, EBS and repository designs might be relied upon by DOE to meet performance objectives and design requirements for which compliance is not demonstrated during the pre-licensing stage. Resolution of deferred waste package issues should be scheduled for completion prior to submittal of the License Application for Construction of the geologic repository.

Based on current thinking, a comprehensive but preliminary list of issues that should be evaluated with respect to MPC design are given below. Category I lists those issues that should be addressed in the early stages of MPC development and preferably prior to large-scale MPC construction, while Category II lists those issues for which resolution may be deferred but which DOE must address before submitting a license application for construction of the geologic repository for disposal of HLW. The method by which DOE addresses technical issues will be chosen by DOE. If DOE chooses to address issues in one or more topical reports, NRC would expect to play a role in technical exchanges to define the scope and content of such topical reports.

CATEGORY I: ISSUES WHICH SHOULD BE ADDRESSED DURING EARLY STAGES OF MPC DEVELOPMENT

- Criticality Control
  - Neutron Absorber Essential for Criticality Control
  - Axial Burnup Variation
  - Highly Enriched Uranium Disposal
  - Long-Term Integrity of Basket and Poisons
- Testing and Verification
  - Inspectability before Disposal
- Potential Negative Performance Credit versus Zero Performance Credit for MPC
- Spent Fuel Integrity and Characterization
  - Methods to Accurately Assess Actual Isotope Concentrations within a Fuel Bundle
    - Individual Fuel Rod Exchange or Rod Consolidation at Reactor
    - Assumptions About Isotope Concentrations
    - Fuel Bundle Isotope Mapping Techniques Development (and Effects on Early Mapping)
    - Variables in Gross Neutron and Gross Gamma Measurements
      - Initial Fuel and Cladding Constituents
      - Effective Full Power Hours of Exposure
      - Neutron Flux Densities during Exposure
      - Time History versus Neutron Flux Density
      - Decay Periods
      - Physical Dimensions
      - Emission Energy Spectrum
  - Methods to Predict Long-Term Neutron Reflection, Multiplication, Moderation, and Absorption within the Waste Package
    - Amount of Water and other Moderators (e.g., beryllium, deuterium, or graphite)
    - Amount of Actinide Concentrations in a MPC
    - Amount of Heat Generated in a Waste Package

- Amount of Selective Leaching of Poisons from the SNF and the Waste Package
- Methods to Predict Long-Term Geometric Changes in the SNF
  - Dimensional Changes Due to Irradiation
  - Fuel Collapse (Consolidated) or Original Fuel Bundle Configuration
  - Dissolution and Movement of the SNF to a Configuration More Likely to Become a Critical Mass (a k_{eff} greater than one)
- Consolidation of Particulates
- Physical Changes from that of Assumed Fresh Fuel
  - Removal of Fissionable Materials (e.g., ^{234}U)
  - Accumulation of Fission Products that are Neutron Absorbers
  - Accumulation of New Fissionable Materials (e.g., ^{239}Pu)
  - Decay of Fission Products that are Neutron Absorbers
  - Decay of New Fissionable Materials

Internal Issues for MPC
- Spent Fuel: Loading, Cladding Integrity (Thermal Effects) and Degradation
- Inspection and Testing

Thermal Loading Design for MPC
- Preclusion of Thermal Load Design Options
- Basket Essential for Heat Distribution
- Incompatibility of 21 PWR design with cold repository design
- Repository Thermal Loading Strategy
- Preliminary or Scoping Performance Assessment/IPA3 and DOE similar analysis
- Effects on Moisture Distribution
- Large Localized Radiation and Thermal Pulse and Gradient

Loss of Containment at MPC Wall Penetrations (e.g., valves, etc.)

Materials Issues for MPC Shell
- Current Candidate Materials
  - Type 316L SS (Considered Baseline Material for MPC Design)
    - Weld Embrittlement (Duplex Structure) material
    - Apply reactor experience
  - Alloy 825 (Considered Potential Alternative Material)
    - Embrittlement of Weld or Base Material
    - Currently insufficient information to determine long-term thermal stability
- Performance/Corrosion Factors
  - Localized Corrosion
  - SCC (in combination with thermal stability)
  - Hydrogen Embrittlement (Galvanic Action)
  - Embrittling Phases due to Thermal Exposure
  - Galvanic Effects

Materials Stability Issues for Internal Components of the MPC
- Effect of Aging on Mechanical Properties
  - Structural Stability of Borated Alloys (Type 316 SS-boron)
  - Structural Stability of Basket Material (Type 316 or 316L SS, Alloy 825)

Long-Term Damage to MPC
- Effects of Transportation and Storage History on Performance
- Handling at Repository
- Emplacement Details
- Difficulty of Handling Large, Heavy Waste Packages

Additional Barrier
Alloy 400 (Ni-30Cu)
Sulfur Segregation, Nickel Clustering (Effects not studied)
Localized Corrosion
Microbial Influenced Corrosion
CDA 715 (Cu-30Ni)
Sulfur Segregation, Nickel Clustering (Effects not studied)
SCC in Slightly Alkaline Environment (Not studied)
Microbial Influenced Corrosion
Handling at Repository
Rail Emplacement Transport Secondary Effects
Capacity of Emplacement Track & its Foundation
Stray Current Corrosion
Effects of Man-Made Materials on Performance (concrete, hydraulic fluids, engine exhaust, etc.)
Importance of the Integrated Approach to Design & Review

4.2.4 Implementation

4.2.4.1 Review Responsibilities

TBD

4.2.4.2 Interfaces

TBD

This section has not been developed at this time. However, the following preliminary information is provided. Similar input information is expected for both CDM 5.2 and CDM 5.4. For brevity, it is not listed here and not repeated for Review Plan 5.4.

4.2.4.3 Input Information

Input Information	Review Plan No.
A description of the kind, amount, and specifications of the radioactive material proposed to be incorporated into waste packages for disposal at the GROA.	2.5 — Radioactive Material

Input Information	Review Plan No.
A description of the geologic conditions of the geologic setting, including descriptions of their effects on waste package design and performance. Examples include descriptions of stratigraphic or lithologic units surrounding or hosting (repository horizon) the waste; seismicity of the geologic settings and geologic structures; tectonism, metamorphism, plutonism, and volcanism with attendant hydrothermal processes; geoengineering properties; design response spectra corresponding to the design basis earthquake; and an assessment of future changes that might be expected to occur in the geologic system.	3.1.1 — Geologic System
The hydrologic conditions of the geologic setting surrounding or hosting (repository horizon) the waste, and descriptions of hydrologic effects contributing to potential waste package degradation mechanisms. Examples include rates of such hydrologic effects; water flow rates and directions; observed hydraulic gradients both within and between individual hydrogeologic units; and predicted hydrologic response to thermal loading from waste packages.	3.1.2 — Hydrologic System
Geochemical properties and conditions of the site that characterize the geochemistry of waste package degradation and radionuclide mobility. Examples include description and analyses of the ground-water chemistry; information on anomalies, properties, and conditions affecting the stability of geochemical characteristics; and properties that exist and changes that might reasonably be expected to occur in the future.	3.1.3 — Geochemical System
The anticipated response of the geomechanical, hydrologic, and geochemical subsystems to the maximum design thermal loading, given the pattern of fractures and other discontinuities and the heat transfer properties of the rock mass and ground water. Variability and uncertainty of data and information and the propagation of errors.	3.1.5 — Integrated Natural System Response to the Maximum Design Thermal Loading

Input Information	Review Plan No.
Identification of structures, systems, and components of the GROA that are important to safety, waste isolation, or retrievability, along with comparative evaluations of these design features with particular attention to alternatives that would provide for longer radionuclide containment and isolation. The basis for the GROA design, including the characteristics of the waste and its package, the characteristics of the emplacement site, and the repository functions. Data on engineered components that are placed near the waste package, such as injected grouts, backfill, and liners. Schedules for the receipt and emplacement of waste.	4.1 — Description of the GROA Structures, Systems, and Components
The layout, design bases, design descriptions and location of the surface facilities, including the hot cell and its components for receiving, transporting, handling, storing, treating, or preparing waste for transfer and final disposal in the underground facility. Description of equipment design features of components of the hot cell which interact with the waste package. Specific design provisions for waste retrieval operations and temporary storage facilities.	4.1.1 — Surface Facilities
Layout, design bases, and design descriptions of all shafts and ramps connecting the surface facilities with the underground facility waste emplacement area; identification of all structures, systems, and components important to safety, retrievability, or isolation and with which the waste package interacts. Describe the waste ramp, personnel and materials ramps, portals, liners (if any), general waste hauling arrangements, ventilation intake shafts, ventilation exhaust shafts, operational and post-closure seals (if any), linings, and drainage. Safety measures to be used to prevent accidents. Average and maximum quantities of ventilation air. The backfilling and sealing system that will be used to permanently close the shafts or ramps.	4.1.2 — Shafts and Ramps

Input Information	Review Plan No.
Layouts, design bases, and design descriptions of the underground facility, including waste emplacement areas, waste transport areas, and other underground areas which might impact waste package integrity, including backfill materials used around the waste packages. Identification of all structures, systems, and components in the underground facility which are important to safety, retrievability, or isolation and their interactions with the waste package. Describe sealing and drainage, extent of the damaged zone around openings, excavation methods, ground support systems, short- and long-term stability of excavated openings, response of these support systems under thermal loading and retrieval conditions, and ventilation air flows. Design bases, and characteristics of wastes and waste packages. Description of waste package transport, emplacement, and retrieval machinery. Descriptions of design bases and details of retrieval plans.	4.1.3 — Underground Facility
Description of how the radiological designs of the surface and underground physical facilities in the GROA will permit safe handling and storage of radioactive wastes during operations and retrieval. Layout drawings should show shield wall thicknesses and waste package shielding requirements. Discussion of the radiological safety features in the designs for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste.	4.1.4 — Radiation Protection Systems
Description of structures, systems, and components that provide interface between the surface facilities, shafts or ramps, and the underground facility for HLW package handling and emplacement.	4.1.5 — Interfaces Between Structures, Systems, and Components

Input Information	Review Plan No.
A description of the waste package design and alternative designs, including the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. A discussion of any coatings, liners, or fillers that may be incorporated in the container design. Materials specifications and general manufacturing methods used. Intended functions, including any assigned performance allocation, of each component of the waste package. Summary of the comparative evaluation of the alternative waste package designs with particular emphasis on those features that would provide longer radionuclide containment and isolation. Assessment of compliance/noncompliance with waste package design requirements.	5.1 — Description of Engineered Systems and Components That Provide a Barrier between the Waste and the Geologic Setting
Design bases, design criteria, and general description of the design of the waste package and alternative designs, including the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. A discussion of any coatings, liners, or fillers that may be incorporated in the container design. Materials specifications and general manufacturing methods used. Intended functions, including any assigned performance allocation, of each component of the waste package. Summary of the comparative evaluation of the alternative waste package designs with particular emphasis on those features that would provide longer radionuclide containment and isolation. Assessment of compliance/noncompliance with waste package design requirements.	5.2 — Assessment of Compliance with the Design Criteria for the Waste Package and its Components

Input Information	Review Plan No.
Design bases, design criteria, and general description of the design of the portions of the underground facility (e.g., the openings and backfill materials) that are considered part of the engineered barrier system; including their interactions with the waste package and provisions provided for retrieval. Examples include descriptions of the waste emplacement areas, panels, emplacement drifts, boreholes, and backfill materials (including backfill properties which affect the design or performance of the waste package). Design bases, design criteria, and design descriptions of the emplacement and retrieval machinery. A description of pre-emplacement site conditions.	5.3 — Assessment of Compliance with the Design Criteria for the Post-Closure Features of the Underground Facility
An assessment of how the waste package and EBS comply with containment and release rate requirements, respectively, including, as a minimum, discussions of the following: (1) EBS and waste package performance assessment codes, including waste package design parameters used as inputs; (2) Assumed anticipated processes and events as well as degradation scenarios; (3) Extrapolation of short-term measurements to long-term predictions of EBS and waste package performance; (4) Uncertainties in the data for waste package design parameters related to the performance assessments; (5) Allocation of performance to each of waste package components; (6) Comparative evaluation of the alternative waste package designs, with particular emphasis on those features that would provide longer radionuclide containment and isolation. Assessment of compliance or noncompliance with 10 CFR Part 60 performance objectives of containment and gradual release for the waste package design.	5.4 — Assessment of Engineered Barrier System Compliance with the Performance Objectives

Input Information	Review Plan No.
Discussion of the program established at the GROA for monitoring the condition of the waste packages, including the waste form, in situ waste package monitoring, radiation, temperature, repository water, and mechanical properties. Description of surveillance, measurements, experiments, and in-situ tests to provide reasonable assurance that design parameters are confirmed. Description of the program for monitoring the external environment of the waste packages. Description of laboratory waste package monitoring and the duration of the performance confirmation program for the EBS.	8.3 — Performance Confirmation Program for the Engineered Barrier System

4.2.5 Example Evaluation Finding(s)

TBD

4.2.6 References

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4.3 REVIEW PLAN 5.4—ASSESSMENT OF ENGINEERED BARRIER SYSTEM COMPLIANCE WITH THE PERFORMANCE OBJECTIVES

4.3.1 Applicable Regulatory Requirements

The subject of this review plan is an assessment of compliance with the performance objectives for the EBS called for in 10 CFR 60.21(c)(1)(ii), as applicable:

§ 60.21(c)(1)(ii)(C)
§ 60.21(c)(1)(ii)(D)
§ 60.21(c)(1)(ii)(F)

For this review plan, the staff will determine if the DOE has demonstrated that the regulatory requirements, defined in 10 CFR 60.113(a)(1)(a)-(c), to assess compliance of the EBS with the performance objectives, has been met.

§ 60.113(a)(1)(i)(A)-(B)
§ 60.113(a)(1)(ii)(A)-(B)
§ 60.113(b)(1)-(4)
§ 60.113(c)

§ 60.122(a)(1)
§ 60.122(A)(2)

4.3.2 Review Strategy

4.3.2.1 Acceptance Review

To determine whether this section of the DOE's license application is acceptable for docketing, the staff will determine whether the information submitted is consistent with that identified in the corresponding section of the Regulatory Guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG).

Before the receipt of the license application, the staff will have conducted pre-licensing reviews of DOE's program, including technical reviews and quality assurance reviews and audits. The staff will have documented its concerns, resulting from these pre-license application reviews, as open items. Some of these open items, referred to as objections to license application submittal, may be critical to the staff's license application review, because lack of acceptable DOE resolution would prevent NRC from

conducting a meaningful review. Therefore, as part of its Acceptance Review for docketing, the staff will evaluate how significant any unresolved objection to license application submittal is, to the effective conduct of licensing activities, using the criteria given in Section 3.1 of this review plan.

4.3.2.2 Compliance Review

Safety Review

This regulatory requirement topic is limited to consideration of assessment of compliance with the subsystem performance objectives for the EBS. It is not concerned with assessment of compliance with the design criteria for either the EBS and its components (including the waste packages) or with the postclosure design features of the underground facility. These topics are covered, respectively, in Sections 5.2 and 5.3 of the license application and the attendant review plans.

In conducting the Safety Review, the reviewers will, as a minimum, determine the adequacy of the data and analyses presented in the license application, to determine DOE's compliance with 10 CFR 60.113(a)(1). The specific aspects of the license application on which the reviewer will focus are described below, and the Acceptance Criteria are identified in Section 3.0 of this Review Plan.

The Safety Review will assess whether the waste packages provide substantially complete containment (with reasonable assurance) and whether the waste packages and the other components of the EBS meet the gradual release requirement (with reasonable assurance). The staff's objectives in the Safety Review are to:

(i) Understand and evaluate DOE's compliance demonstration logic

(ii) Conduct a preliminary review of the data base used for compliance demonstration, to determine which parts of the data are most uncertain or may be incomplete

(iii) Determine whether portions of the data and/or analyses submitted should be subjected to further detailed review (in addition to those areas requiring detailed Safety Reviews specified below)

(iv) Determine whether the use of expert opinion (if used) was appropriate.

In general, the reviewers will assess the adequacy and completeness of DOE's analyses of the design of the waste packages and the EBS, with respect to the performance objectives for containment and gradual release from the EBS. The Safety Review will determine whether DOE's assessment shows that all anticipated processes and events have been considered and analyzed. For disposal in the repository domain, the Safety Review will also determine whether DOE's assessment shows that both the partial filling and complete filling, with groundwater, of available void space in the underground facility, have been considered and analyzed, per 10 CFR 60.113(a)(1)(i)(B).

The Safety Review will also determine whether DOE's assessment shows that: (1) all the favorable conditions and potentially adverse conditions, that are characteristic of the site, have been considered in the demonstration for the EBS performance objectives expressed in 10 CFR 60.113(a)(1); and (2) the assumptions made in examining each potentially adverse condition are not likely to underestimate the effects of that condition on the EBS performance objectives expressed in 10 CFR

60.113(a)(1). Only anticipated processes and events will be considered in the assessment. [For disposal in the repository domain, both partial and complete filling, with groundwater, of available void space in the underground facility, should also be appropriately considered and analyzed, per 10 CFR 60.113(a)(1)(i)(B).]

To conduct an effective review, the reviewer will rely on staff expertise and independently-acquired knowledge, information and data such as the results of research activities being conducted by the NRC Office of Nuclear Regulatory Research, in addition to that provided by DOE in its license application. Therefore, each reviewer should have acquired a body of knowledge regarding critical considerations, in anticipation of conducting the safety review, to ensure that the information provided is sufficient to resolve concerns. At a minimum, each reviewer must be familiar with the experiments and analysis on EBS concepts sponsored by DOE (e.g., Chambre et al., 1986; Van Konynenburg et al., 1986; Mallet, 1986; Liebetrau et al., 1987; Zwahlen et al., 1989; Apted et al., 1990; Light et al., 1990; Sadeghi et al., 1990; Wilson, 1990; Zwahlen et al., 1990; Farmer et al., 1991; Lee et al., 1991; Lee and Choi, 1991; Leider et al., 1991; Pescatore and Sullivan, 1991; and Ueng and O'Connell, 1992) and NRC (e.g., Interrante et al., 1987a, 1987b, 1988a, 1988b, 1989, 1990, 1991, and 1993; Manaktala and Interrante, 1990; Wu et al., 1990; Nataraja and Brandshaug, 1992: and Sridhar et al., 1993), and more current works, as they become available.

It should be noted that 10 CFR 60.113(b) provides for alternate radionuclide release rates and/or waste package containment periods. Should DOE implement this provision, the reviewers will, as a minimum, determine the adequacy of the data and analyses presented in the license application, to determine DOE's compliance with any alternate radionuclide release rates and /or waste package containment periods proposed. Accordingly, the Review Strategy described above would still apply.

Detailed Safety Review Supported by Analyses

A Detailed Safety Review and Analysis will be needed for evaluation of the KTUs related to: (1) thermomechanical effects on the waste packages and the EBS; (2) environmental effects on the waste packages and EBS; (3) criticality events in waste packages; (4) release path parameters (such as the size, shape, and distribution of penetrations of waste packages) due to thermomechanical, environmental, or criticality effects; (5) the releases of gaseous radionuclides from waste packages during the containment period and from the EBS during the post-containment period; and (6) the releases of non-gaseous radionuclides from waste packages, during the containment period, and from the EBS during the post-containment period. This review will make use of data, models, analyses, and methodologies developed by DOE and/or other parties and reviewed and found acceptable by the staff. This will ensure that DOE has adequately demonstrated Items (1) to (4), listed in the previous section ("Safety Review," paragraph 3). Probability and uncertainty analyses will be used to identify critical parameters whose associated uncertainties contribute in a major way to demonstration of compliance with the performance objectives. Activities performed in this Detailed Safety Review will help to ensure that DOE has adequately addressed and resolved these KTUs so that they do not lead to non-compliance with the EBS performance objectives.

The Detailed Safety Review of the KTU related to thermomechanical effects will require the staff to examine closely the data, analyses, and assumptions used by DOE to analyze thermomechanical effects on the waste packages and the EBS. The staff must determine whether all reasonable thermomechanical effects have been considered by DOE and that the models used by DOE are not likely to underestimate the consequences of the thermomechanical effects on the structural integrity of the waste

packages and the EBS. Detailed reviews will be supported by the staff's own analyses, including the use of data and analytical models not considered by DOE, if appropriate.

The Detailed Safety Review of the KTU related to environmental effects will require the staff to examine closely the data, analyses, and assumptions used by DOE to analyze environmental effects on waste packages and the EBS. The staff must determine whether or not all reasonable environmental effects have been considered by DOE, and that the models used by DOE are not likely to underestimate the consequences of the environmental effects on the structural integrity of the waste packages and the EBS. Detailed reviews will be supported by the staff's own analyses including the use of data and analytical models not considered by DOE, if appropriate.

The Detailed Safety Review of the KTU related to criticality events in waste packages will require the staff to examine closely the data, analyses, and assumptions used by DOE to predict criticality events. The staff must determine whether the models used by DOE are not likely to underestimate the probability of a criticality event. Detailed reviews will be supported by the staff's own analyses, including the use of data and analytical models not considered by DOE, if appropriate.

The Detailed Safety Review of the KTU related to release path parameters (such as the size, shape, and distribution of penetrations of waste packages) due to thermomechanical, environmental, or criticality effects will require the staff to examine closely the data, analyses, and assumptions used by DOE to predict the penetrations of waste packages due to those effects. The staff must determine whether the models used by DOE are not likely to underestimate the penetrations of waste packages. Detailed reviews will be supported by the staff's own analyses, including the use of data and analytical models not considered by DOE, if appropriate.

The Detailed Safety Review of the KTU related to releases of gaseous radionuclides from waste packages during the containment period and from the EBS, during the post-containment period, will require the staff to examine closely the data, analyses, and assumptions used by DOE to predict the transient generation and release of gaseous radionuclides. The staff must determine whether the models used by DOE are not likely to underestimate the quantities of gaseous radionuclides generated and released. Detailed reviews will be supported by the staff's own analyses, including the use of data and analytical models not considered by DOE, if appropriate.

The Detailed Safety Review of the KTU related to releases of non-gaseous radionuclides from waste packages, during the containment period, and from the EBS, during the post-containment period, will require the staff to examine closely the data, analyses, and assumptions used by DOE to predict the release rates of non-gaseous radionuclides through penetrated waste packages, and the subsequent transport of non-gaseous radionuclides to the boundaries of the EBS. The staff must determine whether the models used by DOE are not likely to underestimate the release rates of non-gaseous radionuclides. Detailed reviews will be supported by the staff's own analyses, including the use of data and analytical models not considered by DOE, if appropriate.

Detailed Safety Review Supported by Independent Tests, Analyses, or Other Investigations

A Detailed Safety Review, Independent Staff Modeling, and the use of the Results of Staff Investigations will be needed for the KTU related to the extrapolation of short-term laboratory and prototype test results, to predict long-term performance of waste packages and EBS. This will ensure that

DOE has adequately demonstrated Items (1) to (4) listed in Section 2.2.1 (see "Safety Review," paragraph 3).

To evaluate this KTU, the staff must review the waste package and EBS degradation modes considered by DOE, to determine whether anticipated processes and events will not result in any credible degradation modes not analyzed by DOE. In conducting this review, each reviewer must have developed an understanding of the credible degradation modes that have been identified in DOE studies (e.g., Farmer et al., 1991) and in NRC and other independent studies (e.g., Manaktala and Interrante, 1990).

The staff must also review DOE's data extrapolation procedures, to ensure that these procedures are supported by the appropriately conservative mechanistic models of the long-term performance of the waste package. If DOE proposes to use natural analogs as part of these data extrapolation procedures, the staff must determine whether the data and conclusions based on the analogs are not likely to result in non-compliance with the EBS performance objectives. In conducting this review, the staff must have developed an understanding of the degradation mechanisms that have been identified in DOE studies (e.g., Farmer et al., 1991) and in independent NRC studies (e.g., "The Integrated Waste Package Experiments Project").

Finally, the staff must review DOE's formal procedures for the elicitation of expert judgment, if used, to ensure that the use of the data and conclusions generated is not likely to result in non-compliance with the EBS performance objectives. In conducting this review, the staff must have developed an understanding of formal elicitation procedures that have been successfully used, to address other complex technical issues (e.g., Nuclear Regulatory Commission, 1990).

4.3.3 Review Procedures and Acceptance Criteria

TBD

4.3.3.1 Acceptance Review

TBD

4.3.3.2 Compliance Reviews

TBD

At the time of development of the Plan for the Technical Review of Waste Packages Containing MPCs, review procedures and acceptance criteria have not been developed. However, certain technical issues have been identified with the MPC design which require early attention and which would be subjects of technical exchanges with DOE. A preliminary list of technical issues that need to be addressed with respect to the MPC and repository disposal has been developed. For both review plans 5.2 and 5.4, similar issues are expected to be important, although these issues may be more clearly aligned with either review plan 5.2 or 5.4 in the future. For brevity, the list of issues is not repeated here. The reader is directed to Section 4.2.3 for the list of issues.

4.3.4 Implementation

4.3.4.1 Review Responsibilities

TBD

4.3.4.2 Interfaces

TBD

This section has not been developed at this time. However, for informational purposes, the following preliminary information is provided. Similar input information is expected for both CDM 5.2 and CDM 5.4. For brevity, it is not repeated here. The reader is directed to Section 4.2.4 for a table of input information needed from other review plans.

4.3.5 Example Evaluation Finding(s)

TBD

4.3.6 References

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5 INTERACTIONS WITH DOE

5.1 TECHNICAL EXCHANGES

Communication with and guidance from NRC during technical exchanges will not constitute a compliance review for approval of the MPC design, and this concept should be conveyed to DOE during such discussions. The difference in timing between near-term licensing of storage and transportation aspects needs to be emphasized to DOE during discussions on disposal aspects, for which licensing will not occur until after the LA for construction has been reviewed.

Before making major financial commitments for design and development of the MPC, DOE may elicit NRC staff opinion on the acceptability of the MPC. The technical exchanges which DOE is planning to schedule during FY95-98 with the NRC should facilitate early review of technical concerns in the MPC program. Prelicensing consultation between NRC and DOE offers an opportunity for the staff to advise DOE of NRC's opinions concerning a specific waste package, subject to such qualifications as may be appropriate. If DOE does not provide adequate or sufficiently persuasive information to NRC on a MPC design, the Director can send comments, or even objections, to DOE. Such objections are not legal restraints, but they would likely guide DOE to proceed with caution.

5.2 REVIEW OF DOE SEMIANNUAL SITE CHARACTERIZATION REPORTS

The NWPA requires DOE to include a description of the possible HLW form and waste packages in the SCP for NRC review and comment. The law also requires semiannual reporting of "site characterization activities," which should include current information on the waste form and package research (and design). In 10 CFR 60.18(g), DOE is required to report semiannually on progress of waste form and waste package research and development.

Thus, DOE's semiannual site characterization report should be reviewed for information upon which the staff may choose to comment on DOE's progress and plans for the MPC. Also in their semiannual site characterization reports, DOE is expected to report activities on developing alternative designs [alternative designs are required by 10 CFR 60.21(c)(ii)(D)], and these should be likewise reviewed for possible NRC comment.

APPENDIX A

EXCERPTS OF REQUIRED INFORMATION FROM FCRG

EXCERPTS OF REQUIRED INFORMATION FROM FCRG

Following are excerpts from the FCRG that identify required information for the License Application to construct the geologic repository for HLW. The excerpts are taken from Review Plans 5.1, 5.2, and 5.4, which deal with EBS description, waste package design criteria, and EBS performance, respectively.

The description and evaluation of the EBS should include a discussion of the overall purpose and function of the EBS and how the EBS fulfills the requirements of 10 CFR Part 60.

A.1 DESCRIPTION OF ENGINEERED SYSTEMS AND COMPONENTS THAT PROVIDE A BARRIER BETWEEN THE HIGH-LEVEL WASTE AND THE GEOLOGIC SETTING

The EBS is composed of the waste packages, including the waste form, and the underground facility. This section should provide a description of the EBS and components as well as their intended functions and relations in the overall repository design. Identify structures, systems, and components of the EBS, and indicate whether or not they have been classified as important to safety, retrievability, or isolation.

A.1.1 Waste Package (Design Description, Purpose and Function, Materials, Alternative Materials, and Designs Considered)

This section should provide a description of the waste package design and alternative designs. The description should include all waste package components, including the waste form and any containers, shielding, packing, and absorbent materials immediately surrounding an individual waste container. The description should also include a discussion of any coatings, liners, or fillers that may be incorporated in the container design. Identify the materials specifications and general manufacturing methods used. Describe the intended functions, including any assigned performance allocation, of each component of the waste package. Describe the comparative evaluation of the alternative waste package designs with particular emphasis on those features that would provide longer radionuclide containment and isolation.

A.1.2 Waste Form

In this section, provide the following information about the waste form to be emplaced in the repository.

(1) Kinds and sources of waste.

(2) Total volume of waste and kinds of waste to be emplaced in the repository and the emplacement schedules.

(3) Physical, chemical, thermal, and radiological characteristics of waste and waste forms.

(4) Waste form handling, treatment (e.g., spent fuel rod consolidation and vitrification of HLW), and acceptance processes and activities. In this section, describe treatments, manufacturing processes, and acceptance procedures used to ensure the high quality of the packaged waste form. This information is typically provided in waste acceptance specifications, waste form compliance plans, waste qualification reports, and waste process control program plans.

A.1.3 Underground Facility

Provide a general description of the design of the underground facility, including descriptions of the waste emplacement areas, panels, emplacement drifts, and boreholes. The discussions should include design descriptions of the portions of the underground facility (e.g., the openings and backfill materials) that are considered part of the EBS; include the provisions provided for retrieval. Backfill materials used in the emplacement drifts and boreholes and other drifts (mains, submains, etc.) should be described, discussing backfill particle size distributions; physical and chemical characteristics; density after emplacement; changes in density and physical and chemical characteristics with time; mechanical, thermal, and thermomechanical properties; emplacement machinery; and capability for retrieval or removal.

A.1.4 Engineered Barrier System/Waste Package Emplacement Environment

This section should describe the environment that will be experienced by the EBS and the waste package. A description of pre-emplacement site conditions should be provided, including ambient temperature; mechanical, physical, and chemical properties of the host rock; the geology of the site (e.g., faultic and seismic information); and the "average" water chemistry and water flow rate. Also discuss how the construction of the repository and the emplacement of wastes surrounded by backfill will change the emplacement environment. This section should also describe the expected post-closure temperature profile with time of the backfill or packing around the waste packages and the characteristics of the ground water at the outermost boundary of the waste package compared with that at the interface of the backfill or packing and the next package component.

A.2 ASSESSMENT OF COMPLIANCE WITH 10 CFR PART 60

The assessment of compliance with 10 CFR Part 60 should be in two parts: the assessment of compliance with particular barriers in regard to design requirements and the assessment of compliance with performance objectives.

A.2.1 Assessment of Compliance for Particular Barriers

This section should assess (1) how the waste package, including the waste form and the underground facility, complies with the design requirements of 10 CFR 60.135 and (2) how the EBS and the waste package comply with the performance objectives.

A.2.1.1 Waste Package Design Requirements

Discuss design criteria for HLW packages and the following:

(1) Consider how the HLW package designs will not compromise the function of the waste packages, the performance of the underground facility, or the geologic setting

(2) Consider solubility, oxidation/reduction reactions, corrosion, hydriding, gas generation, thermal effects, mechanical strength, mechanical stress, radiolysis, radiation damage, radionuclide retardation, leaching, fire and explosion hazards, thermal loads, and synergistic interactions

(3) Consider (a) explosive, pyrophoric, and chemically reactive materials, (b) free liquids, (c) handling, and (d) unique identification

Discuss any applicable industry codes and standards that were used in the design. Identify the value of design parameters used to meet the design criteria, including the parameters. Describe any uncertainties associated with the parameters and the treatment of those uncertainties. Justify how these parameters result in compliance with the applicable requirements of 10 CFR Part 60.

Describe the modeling methods used to demonstrate that the design parameters are met. Provide an explanation of the measures supporting the models used to perform the analyses. Analyses and models used to predict future conditions and changes in the waste package or its environment should be supported.

For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness, as well as uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

For design criteria for other than HLW packages, provide the information for those packages as discussed above.

A.2.1.2 Waste Form

Discuss how waste form criteria for HLW are met with regard to (1) solidification, (2) consolidation, and (3) combustibles.

In general, describe the design parameters that have been established to comply with the waste form criteria and the basis for those parameters. Identify any uncertainties associated with the design parameters and the treatment of those uncertainties. Discuss the modeling method used to demonstrate that the design parameters are met. Provide an explanation of measures supporting the

models used to perform analyses. Analyses and models used to predict future conditions and changes in the waste form should be supported.

For both design applications and accident analyses, an explanation of measures supporting the models used to perform analyses should be provided. Analyses and models that have been used to predict future conditions and changes in the system should be supported by using an appropriate combination of such methods as field tests, in situ tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies. The variability and uncertainty of data and the propagation of errors should be discussed. The discussion should include evaluations of data representativeness, as well as uncertainties associated with the extrapolation of data. Also, conceptualizations and the documentation and validation of codes and models used should be discussed with respect to uncertainties related to the data on which the model is based, the applicability of specific models, the appropriateness of assumptions used in modeling, and the sensitivity of model results to the uncertainty of the input data. Input and output data and interpretations should also be provided along with the basis for the interpretation. Sufficient detail should be provided to allow independent analysis of results. When it was used, the role of expert judgment should be documented.

A.2.2 Assessment of Compliance with Performance Objectives

Provide an assessment that describes how the waste package and EBS comply with containment and release rate requirements, respectively. As a minimum, the assessment should discuss in detail the following:

(1) EBS and waste package performance assessment codes, including supporting research, testing, and model development

(2) Assumed anticipated processes and events as well as degradation scenarios

(3) Extrapolation of short-term measurements to long-term predictions of EBS and waste package performance

(4) Uncertainties in the data, models, codes, and results related to the performance assessments

(5) Allocation of performance to each of the EBS or waste package components

(6) Comparative evaluation of the alternative waste package designs, with particular emphasis on those features that would provide longer radionuclide containment and isolation

If a radionuclide release rate or designed containment period other than those nominally specified in 10 CFR 60.113(a) is proposed, the assessment should identify it and provide a rationale, taking into account the factors set out in 10 CFR 60.113(b).

A.2.2.1 Containment

In this section, evaluate whether containment of the HLW within the waste package will be substantially complete during the period when radiation and thermal conditions in the EBS are dominated by fission product decay. The duration of this period will be determined by the NRC, taking into account the factors specified in 10 CFR 60.113(b), provided that such period will not be less than 300 years nor more than 1,000 years after permanent closure. Address sources of uncertainties and discuss how the concept of "substantially complete containment" is satisfied. This section should include consideration, to the extent pertinent, of the favorable and potentially adverse conditions described in 10 CFR 60.122 and should show compliance with the requirements of that section.

A.2.2.2 Release Rate

Provide the projected release rate of any radionuclide from the EBS following the containment period defined in the previous section, and evaluate such release rate in accordance with the requirements of 10 CFR 60.113(a)(ii)(B). This section should include consideration, to the extent pertinent, of the favorable and potentially adverse conditions described in 10 CFR 60.122 and should show compliance with the requirements of that section.