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REGULATORY PROCEDURES AND TECHNICAL CONSIDERATIONS RELATED TO NRC'S REVIEW OF THE MPC DESIGN CONCEPT

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1 INTRODUCTION AND BACKGROUND

The U.S. Department of Energy (DOE) is responsible for the disposal of high-level radioactive waste (HLW) in the United States. DOE is seriously considering the use of a multi-purpose canister (MPC) concept as part of their advanced conceptual design (ACD) for a package for disposal of HLW. The MPC would be a sealed canister which would have the capability of holding multiple spent nuclear fuel (SNF) assemblies. The MPC would be sealed immediately after loading it with SNF, and it would not be opened to remove SNF once sealed. MPCs would be placed in separate overpacks for transportation, storage, and geologic disposal. The MPC is a relatively new design concept for DOE's HLW program, and it is being pursued by DOE on an accelerated basis as a design possibility.

The U.S. Nuclear Regulatory Commission (NRC) has authority to regulate activities associated with the transportation, storage, and disposal of HLW, and the Code of Federal Regulations (CFR), Title 10, Chapter I, contains regulations set forth by the NRC. Part 60 of that chapter addresses "Disposal of High-Level Radioactive Wastes in Geologic Repositories." Regulations for transportation of HLW are contained in Part 71 ("Packaging and Transportation of Radioactive Material"), and HLW storage is the subject of Part 72 ("Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste"). The Center for Nuclear Waste Regulatory Analyses (CNWRA) has been tasked by the NRC to produce a letter report to provide a preliminary assessment of regulatory procedures and technical considerations that relate to DOE's use of an MPC in their waste package (WP) design for the disposal of HLW. The focus of the report is on potential effects on determining compliance with NRC requirements in 10 CFR Part 60. This scoping document is intended to aid the NRC staff in their preparations for a workshop to be sponsored by DOE in November 1993. In further support of NRC's prelicensing interactions with DOE with regard to the MPC concept, CNWRA staff will attend the MPC workshop, with subsequent activities to be determined after the workshop.

For this analysis, two DOE options with respect to engineered barrier system (EBS) performance and MPC design have been considered: credit either will or will not be taken for the canister as a barrier for containment and isolation. In either case, DOE will need to take into account the canister (e.g., corrosion products effects, etc.) during assessment to determine compliance with containment and gradual release requirements. However, if DOE chooses to take credit for the canister as a barrier for containment and isolation, the MPC will assume a more prominent role in compliance with requirements in 10 CFR Part 60. Where appropriate, the impact of DOE's use of the MPC as such a barrier is discussed in this report. For most cases for which the MPC concept will make a difference in NRC's determination of compliance with regulatory requirements, the effect will be amplified if DOE chooses to take credit for the MPC as a barrier to HLW release.

In general, the overriding concern with the MPC design concept is that design decisions which have important performance and regulatory compliance implications will be made for the MPC very early in the process, long before a license application for a geologic repository is submitted. NRC will make compliance determinations on these design decisions only after the license application for the repository is received. DOE will undoubtedly request that NRC express any reservations with DOE's proposed designs during the prelicensing period.

Two important considerations that NRC should consider during interactions with the DOE are: (i) NRC may be required to make compliance determinations early in the process, without the benefit of any results of the waste package environment study; and (ii) no clear link between the MPC concept design

issues and the waste package plan (DOE, 1993a) and implementation plan (DOE, 1993b) appears in the ACD phase of DOE's program.

2 REGULATORY ANALYSES

2.1 REGULATORY REQUIREMENTS FROM CODE OF FEDERAL REGULATIONS, TITLE 10, CHAPTER I

Following is a summary and analysis of NRC requirements from 10 CFR Part 60 which must be considered when examining the MPC concept. Each regulatory requirement which has been cited in one or more of the EBS compliance determination strategies (CDSs numbered 2.5, 5.1, 5.2, 5.3, 5.4, 5.5, and 8.3) is individually considered. In addition, other citations for which determination of compliance may be impacted by DOE's use of the MPC concept have also been considered.

2.1.1 10 CFR 60.21 Content of Application

10 CFR 60.21(c)(1)(ii)(C): This citation requires that the Safety Analysis Report (SAR) (which is part of DOE's repository license application) include an evaluation of post-closure performance for anticipated processes and events, and another evaluation for unanticipated processes and events. No MPC impact expected.

10 CFR 60.21(c)(1)(ii)(D): This citation requires 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." Construction of a number of MPCs in accordance with the MPC concept before the development of the license application design for the WP is submitted could preclude the consideration of alternatives to MPC design and, therefore, not allow the required attention to MPC alternatives. If the MPC were not important to waste isolation (i.e., if the disposal overpack were the only WP component important to waste isolation), this is not a concern. However, the comparative evaluation of design alternatives is significant if potential damage during transportation or storage might compromise long-term performance of the MPC for waste isolation. This is especially so if credit is taken for the MPC as a barrier to HLW release.

10 CFR 60.21(c)(1)(ii)(E): This citation requires that the SAR (which is part of DOE's repository license application) include an analysis and identification of the major structures, systems, and components that are important to safety. The analysis is required so that operations at the geologic repository operations area (GROA) "will be carried out at the maximum capacity and rate of receipt of radioactive waste stated in the application." The phrase "maximum capacity" in this citation might not be clear with respect to the MPC concept. However, the purpose of the citation is "to identify those [structures, systems, and components] that are important to safety," so this should not be significant.

10 CFR 60.21(c)(1)(ii)(F): This citation requires that the license applicant submit "an explanation of measures used to support the models used to perform the assessments" required in 10 CFR 60.21(c)(1)(ii)(C) and 60.21(c)(1)(ii)(D). No MPC impact expected.

10 CFR 60.21(c)(2): This regulatory requirement requires a "description and discussion of the design, both surface and subsurface, of the geologic repository operations area 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 geologic media . . .)." Design bases for the MPC may be different for each of its three functions (transportation, storage, and disposal). Thus, certain

MPC design bases may not relate to general performance objectives nor to principal design criteria in 10 CFR Part 60. Also, sufficient site characterization data may not be available to rationalize the choice of MPC materials of construction. Design bases and decision rationales are of greater relevance for the case in which credit is taken for the MPC as a barrier to HLW release.

10 CFR 60.21(c)(3): The required analysis of structures, systems, and components important to safety (in which the MPC would likely be included) for adequacy in mitigating consequences of accidents would probably also include accidents during transportation and storage, and this was not anticipated for a canister whose only purpose related to disposal at the repository. While storage and transportation requirements in 10 CFR Parts 71 and 72 do require design which considers accidents, the purpose of such requirements is not related to long-term performance of the MPC for disposal of HLW.

10 CFR 60.21(c)(5): The required "description of the kind, amount, and specifications of the radioactive material" would include a description of the MPC in the license application. In order to provide such a description, DOE will need to identify and inventory the HLW at the time it is encapsulated in the MPC. The MPC will be sealed, with no intent for subsequent re-opening, before the license application is submitted. [See also 10 CFR 60.71(b) and 60.135(b)(4).] Additional information may be needed to update the inventory of each sealed MPC prior to disposal.

10 CFR 60.21(c)(6): The rationale for selection of license specifications must be included in the SAR of the license application, in accordance with this regulatory requirement. Choice of the MPC concept would "significantly influence the final design," and license specifications [per 60.43(b)] would include "restrictions as to size, shape, and materials and methods of construction of radioactive waste packaging" and "physical and chemical form and radioisotopic content of radioactive waste." The MPC concept might also influence license specifications concerning "amount of waste permitted per unit volume of storage space" as well as "test, calibration or inspection to assure that the foregoing restrictions are observed." DOE could still meet all these by repackaging, if necessary, prior to disposal, but practical considerations (such as cost) may induce DOE to forego any deviation from MPC which would require repackaging. In such a case, the pertinent license specifications would be determined during MPC design, and NRC's approval of such specifications as a condition of license [60.43(b)] would be limited.

10 CFR 60.21(c)(7): The "program for control and monitoring of radioactive effluents and occupational radiation exposures" is required by this citation to be part of DOE's SAR in their license application. No MPC impact expected.

10 CFR 60.21(c)(14): This regulation requires DOE to identify, in the license application SAR, repository structures, systems, and components which "require research and development [R & D] to confirm the adequacy of design." For those which are "important to safety," a detailed description of such R & D programs is also required. If the MPC requires "research and development to determine adequacy of design" as a component important to safety, such R & D will have to be done after the MPC has been designed and constructed as a component for transportation and storage.

2.1.2 Subpart D—Records, Reports, Tests, and Inspections

The following citations do not originate from the EBS CDSs, but their compliance may be influenced by the MPC concept.

10 CFR 60.71(a): To comply with this requirement, DOE will need to begin their program to maintain records required by other parts of 10 CFR Part 60 [such as 10 CFR 60.21(c)(5), 60.71(b), 60.73, and 60.74] before loading the MPCs with HLW and sealing them. This will occur before the license application has been submitted.

10 CFR 60.71(b): This requirement defines the records which must be maintained as per 10 CFR 60.71(a). Such records are to provide ". . . a complete history of the movement of the waste from the shipper through all phases of storage and disposal." These records are to include ". . . receipt, handling, and disposition of radioactive waste at a geologic repository operations area . . ." It is clear that such records must include "receipt, handling, and disposition" which takes place for the MPC at any site, including spent fuel storage installations or a monitored retrievable storage (MRS) site.

10 CFR 60.73 Reports of Deficiencies: This citation requires that DOE report any deficiencies in the design and construction of the GROA ". . . which, were it to remain uncorrected, could: (a) Be a substantial safety hazard, (b) represent a significant deviation from the design criteria and design bases stated in the application, or (c) represent a deviation from the conditions stated in the terms of a construction authorization or a license, including license specifications." If the MPC is part of the GROA, it is clear that DOE would be compelled to report deficiencies in the MPC of which they become aware prior to submittal of the license application per 10 CFR 60.73. Arguments against such a need to report deficiencies include: (i) since the application has not been submitted, no deviation from design criteria and design bases can be identified; (ii) since no construction authorization, license, or license specifications exist, no deviation from stated conditions can be identified; and (iii) no substantial safety hazard at the repository can be identified until complete EBS and GROA designs are in hand (safety hazards during storage and transportation of MPCs are covered by 10 CFR Parts 71 and 72). It is unclear whether the "design and construction of the geologic repository operations area" would include the design and construction of the MPC.

10 CFR 60.74 Tests: The subject of this requirement includes tests which ". . . the Commission deems appropriate or necessary for the administration of the regulations in this part." During the prelicensing period, the Commission may deem certain tests appropriate or necessary before an application for a license has been submitted. After the license application has been submitted, the opportunity to perform certain tests may be lost, since the MPC will be welded shut years before. The scope of tests may include the MPC, since 10 CFR 60.74 specifically includes tests of "radioactive waste," "geologic repository . . . components," and "equipment and devices used in conjunction with the receipt, handling and storage of radioactive waste." An issue for the future will be to define what tests the Commission deems appropriate or necessary, but it is reasonable to assume that such tests will include waste package acceptability for disposal. Criteria for waste package acceptability for disposal would be based on meeting performance objectives and design criteria from 10 CFR Part 60. If credit is to be taken for the MPC as a barrier to HLW release, the criteria for and the results of these required tests have greater importance. The tests required by 10 CFR 60.74 include the performance confirmation program.

2.1.3 10 CFR 60.111 Performance of the GROA Through Permanent Closure

10 CFR 60.111(a) Protection Against Radiation Exposures and Releases of Radioactive Material: This citation defines the radiation protection performance objective for the GROA. This will only be affected by the MPC design concept if (i) the MPC concept includes a radiation protection

function during repository operations, or (ii) radiation protection functions interact with the MPC to negatively impact EBS long-term performance.

10 CFR 60.111(b) Retrievability of Waste: This regulatory requirement defines retrievability as one of the pre-closure performance objectives for the GROA. Although it is not an EBS citation, it is important to the MPC concept. Retrievability could be affected severely for a very large, heavy waste package, such as has been considered for the MPC concept. If backfill is used, removal by overcoring (as has been anticipated for SCP reference design canisters emplaced in backfilled drifts) would not be practical.

2.1.4 10 CFR 60.112 Overall System Performance Objective for the Geologic Repository After Permanent Closure

If compliance with containment or gradual release requirements expressed in 10 CFR 60.113 is not met, a similar effect on overall performance might occur.

2.1.5 10 CFR 60.113 Performance of Particular Barriers After Permanent Closure

10 CFR 60.113(a)(1): Containment and gradual release performance objectives are limited to "anticipated processes and events," which are defined in 10 CFR 60.2 as those "reasonably likely to occur during the period the intended performance objective must be achieved." The period intended for EBS performance objectives is implied in the title of 10 CFR 60.113, "Performance of particular barriers after permanent closure." However, damage to an MPC inside a transportation overpack would occur prior to permanent closure and technically might not be included for EBS as an anticipated process or event. While requirements in 10 CFR Parts 71 and 72 cover damage to an HLW package during transportation and storage, they are not written to address effects of WP damage on long-term, repository performance. For the MPC concept, it is important to include the history of the environment and the damage accumulated during the period prior to disposal. Also, criteria may be needed to determine acceptability of MPCs for disposal.

For release limit calculations, the "inventory of radioactive waste, originally emplaced in the underground facility" might be uncertain. If the MPC within the disposal overpack is the same as that used during transportation and storage (as proposed for the MPC concept), such an inventory would need to be made before the MPC is sealed, which would be expected to be long before the license application is received. Also, the inventory at time of emplacement (years after sealing the MPC) could only be calculated from the initial inventory. Thus, if the accepted standards for measurement an determination of inventory change from the time the MPC is sealed to the time the WP would be accepted for disposal. the sealed MPC would have to be re-inventoried or the MPC would have to be opened to be re-inventoried. Greater accuracy may be required for the inventory methods for WP acceptance for disposal than was available when the MPC was sealed, and the MPC would then need to be re-inventoried to provide the necessary accuracy. For example, if performance assessment calculations indicate that the release rate of a certain radionuclide is acceptable with a 10 percent margin and the accuracy of its original inventory is plus or minus 20 percent, then the MPC would need to be re-inventoried.

10 CFR 60.113(b): Among factors which the Commission would consider when considering case-by-case exceptions for release rate or containment period are the "age and nature of the waste" and "particular sources of uncertainty in predicting the performance of the geologic repository." It is unclear

whether or not pre-emplacement effects of transportation and storage on the MPC or other MPC design considerations would be included in such factors. If not, the Commission may be limited with respect to acceptability of case-by-case exceptions.

2.1.6 10 CFR 60.130 Scope of Design Criteria for the Geologic Repository Operations Area

In addition to defining the scope of design criteria for the GROA, this citation requires that all GROA design bases must be consistent with the results of site characterization activities. The MPC may fit the category of a GROA component important to safety, or at least it is likely to affect the design of GROA structures, systems, or components important to safety, and the MPC would thus be subject to this requirement. The MPC would be designed during the early stages of site characterization. If subsequent site characterization indicates a change in MPC design bases, the design bases for the MPC may not be consistent with the results of site characterization activities.

2.1.7 10 CFR 60.131 General Design Criteria for the GROA

10 CFR 60.131(a)(1) through (6): If shielding and preclosure containment are an integral part of MPC design, these regulations will apply. Also, designing to "limit the time required to work in the vicinity of radioactive materials, including . . . ease of repair and replacement and providing adequate space for ease of operation" will likely involve automated processes and careful space considerations.

10 CFR 60.131(b)(1) through (6) and (8) through (10): If the MPC is relied upon as a structure, system, or component "important to safety," these criteria will apply.

10 CFR 60.131(b)(7): Criticality Control. Each system (for processing, transporting, handling, storage, retrieval, emplacement, and isolation of radioactive waste) must be designed for criticality safety under normal conditions. This citation would appear to encompass any damage to the MPC within transportation and storage overpacks that might affect criticality before or after emplacement at the repository. Burnup and reliance upon installed poisons are not mentioned. Overpacks would likely be designed before licensing, and MPC design would also be accomplished early. It is uncertain if the terminology "normal and accident conditions" would include the postclosure terminology of "anticipated and unanticipated processes and events."

2.1.8 10 CFR 60.133 Additional Design Criteria for the Underground Facility

Very large, heavy WPs incorporating MPCs in disposal overpacks would likely complicate the design of the underground facility to permit retrieval of waste. Multiple MPCs in a single overpack, as considered in the four-canister basket (4CB) for small MPCs, would also complicate retrieval. Design for thermal loads may complicate DOE's plan if the thermal load exhibited by an MPC is greater than desired; HLW would need to be repackaged in such a case. Very heavy WPs may affect underground facility performance by potential damage during overpack transit. The potential for very heavy WPs dictates that access ramps to the underground facility be on a gentler slope, since rail would be used instead of rubber-tired vehicles for WP transport. This will result in much greater excavated volume for access ramps than would have been required for much smaller WPs.

2.1.9 10 CFR 60.135 Criteria for the Waste Package and Its Components

The general concern that design decisions which have important performance and regulatory compliance implications will be made for the MPC before a repository license application is submitted applies most directly to the design criteria in 10 CFR 60.135. Compliance determinations on these design criteria can only be made after the license application for the repository is received, while the design to meet such criteria will be developed by DOE during the prelicensing period.

10 CFR 60.135(a)(1): To meet this design criterion, the waste packages must be designed so that interaction of the emplacement environment with the waste packages does not compromise the function of the waste packages. An assessment of waste package performance for containment and gradual release is not expected to be complete by the time the MPC would be designed. Although DOE may not take credit for the MPC for these waste package functions, the MPC would still be expected to be included to some degree in assessments of waste package performance, at least to show that the MPC does not have a negative impact. Characterization of the emplacement environment will likely be incomplete when the MPC is designed, so calculations of interactions of the MPC part of the waste package with its environment would not be possible at design time.

10 CFR 60.135(a)(2): This citation expounds on factors which must be considered in designing to comply with 10 CFR 60.135(a)(1). Included in the synergistic interactions to be considered could be galvanic corrosion processes arising from the MPC within its disposal overpack. See comments for 10 CFR 60.135(a)(1).

10 CFR 60.135(b)(1): The site may not be characterized to the extent necessary at MPC-design time to determine whether or not a potential exists for the MPC or the HLW to chemically react to the extent that it would compromise the ability of the underground facility to contribute to waste isolation or the ability of the repository to satisfy performance objectives. One approach DOE might adopt is to use bounding values for significant WP environment parameters to make an initial assessment to determine feasibility for use before repository licensing. To comply with 10 CFR 60.135(b)(1), the waste package must not contain such materials in amounts which could compromise performance objectives. If DOE chooses not to take credit for the MPC as a barrier to HLW releases, the possibility exists that they may overlook detrimental secondary effects of MPC corrosion products on waste package performance.

10 CFR 60.135(b)(2): This waste package design criterion concerns free liquids. DOE's demonstration that the waste package does not contain free liquids will rely on measurements made and techniques established before the license application is submitted. Also, the amount of free liquids allowable within the waste package must be less than that which could compromise waste package ability to achieve performance objectives, and DOE's demonstration of such ability will not be finalized until license-application time. The amount of free liquids should be limited within the various overpacks as well as within each MPC. Limitation of free liquids within HLW packages are different for transportation and storage (from 10 CFR Parts 71 and 72) than for disposal (from 10 CFR Part 60).

10 CFR 60.135(b)(3): Per this criterion, waste packages must be designed to contain HLW during handling operations. Consideration of retrievability of very large, heavy emplacement overpacks containing several MPCs without loss of containment has not been shown.

10 CFR 60.135(b)(4): Each waste package must be uniquely and durably identified to comply with this waste package design criterion. Records of waste package identification would necessarily be initiated prior to license application, and legibility of waste package identification is required to at least the end of retrievability. Each MPC must be so identified, and overpacks for transportation, storage, and disposal would need identification as well, in order to determine their contents.

10 CFR 60.135(c)(1): This "solid form" and "sealed containers" requirement for waste package design would need to be met when the MPC is welded shut, before license application submittal. The quality of the seal after transportation and years of storage would require reassessment at the repository.

10 CFR 60.135(c)(2): The requirement for consolidated waste form is complicated by the particulate form of spent fuel within fuel rods. However, it could be argued that the combination of MPC plus overpack equates to a consolidated waste form from the perspective of limiting availability and generation of particulates.

10 CFR 60.135(c)(3): This design criterion requires that combustible HLW be limited within the WP. No MPC impact expected.

10 CFR 60.135(d): This citation states that criteria for radioactive waste other than HLW will be addressed when and if such waste is proposed for disposal at the repository. No MPC impact expected.

2.1.10 10 CFR 60.140 Performance Confirmation Program General Requirements

The performance confirmation program is to begin during site characterization, so its scope could encompass the time during which MPCs are designed and constructed. The performance confirmation program is required to provide data which indicates whether ". . . engineered systems and components required for repository operation, or which are designed or assumed to operate as barriers after permanent closure, are functioning as intended and anticipated" [10 CFR 60.140(a)(2)]. As a component required for repository operation, the MPC would seem to fall within the bounds of the intent of the scope of this requirement. It should be noted that DOE might elect not to assume that the MPCs operate as barriers after permanent closure, since they have already similarly assumed such for the pour canisters for glass waste in the SCP design. However, performance monitoring of MPCs or pour canisters for leak-tightness and level of damage accumulated during transportation and storage will be required to comply with this citation. An "established plan for feedback and analysis of data, and implementation of appropriate action" as required in 10 CFR 60.140(d)(4), would be expected to be shown by DOE if the MPC concept is adopted.

2.1.11 10 CFR 60.142 Design Testing

These *in-situ* tests will occur after repository construction has begun, so the impact of DOE's use of MPCs would not be significant other than ensuring that such tests are planned as part of the Performance Confirmation Program. Thermal interaction effects of the waste package and its emplacement environment are specifically included in 10 CFR 60.142(a). If the thermal loading imposed by an MPC is too great, the HLW within it would need to be redistributed to reduce the thermal load.

2.1.12 10 CFR 60.143 Monitoring and Testing Waste Packages

10 CFR 60.143(a): The purpose of the performance confirmation program with respect to monitoring and testing waste packages is to monitor the condition of the waste packages. MPCs would require tests for leak-tightness and level of damage accumulated during transportation and storage before being accepted for disposal at the repository. Technical difficulties here include monitoring the condition of MPC internal components, including structural integrity of baskets, location and stability of poisons for criticality control, and structural integrity of the spent fuel. Although DOE is not currently proposing a single overpack for transportation, storage, and disposal, with no opportunity for direct inspection of the MPCs within, such a design alternative has not been ruled out. For such a case, these problems would be made worse, since any damage incurred during transportation, for example, would not be directly measurable. If the MPC is relied on by DOE as a barrier to HLW release, difficulties with access for determination of its condition are more significant.

10 CFR 60.143(b): The "environment of the waste packages selected for the waste package monitoring program shall be representative of the environment in which the wastes are to be emplaced." It is unclear whether this environment should include backfill, if used in the final design, or if tests should be done both with and without backfill. No MPC impact is expected.

10 CFR 60.143(c): Laboratory experiments "which focus on the internal condition of the waste packages" would become more important if the MPC concept is adopted. HLW would be inaccessible within MPCs, and MPCs would be inaccessible within disposal overpacks. The internal condition of the waste package might then include the external condition of the MPC. Such experiments may need to include evaluations of potential effects of transportation (and storage) on MPCs. Transportation effects may need to be considered even if separate overpacks are used for transportation, storage, and disposal. The question of including backfill in the emplacement environment duplicated in laboratory experiments is an issue for 10 CFR 60.143(c). If the MPC is considered a barrier to HLW release, then MPC inaccessibility during laboratory experiments may create difficulties in analyzing its behavior and predicting its long-term performance.

10 CFR 60.143(d): This regulatory requirement specifies that the performance confirmation program must continue until permanent closure. No MPC impact expected.

2.2 NRC REVIEW PLANS

Applicable regulatory requirements from 10 CFR Part 60 for each of these EBS review plans have been considered in the previous section. As previously noted, some regulatory requirements from other review plans have also been considered since their compliance may be influenced by the MPC concept.

- Review Plan 2.5—Radioactive Material
- Review Plan 5.1—Description of Engineered Systems and Components That Provide a Barrier Between the Waste and the Geologic Setting
- Review Plan 5.2—Assessment of Compliance with the Design Criteria for the Waste Package and Its Components

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

- Review Plan 5.4—Assessment of Engineered Barrier System Compliance with the Performance Objectives

- Review Plan 5.5—Radiation Protection for Engineered Barrier Systems

2.3 EXISTING POLICIES AND PROCEDURES FOR 10 CFR PARTS 71 AND 72

2.3.1 10 CFR Part 71 and 10 CFR Part 72

2.3.1.1 10 CFR Part 71—Packaging and Transportation of Radioactive Material

Initial consideration of this Part of the regulations was conducted with respect to four considerations as delineated in the following sections:

Requirements which, if met by the applicant in an MPC design, might preclude meeting waste package or EBS performance objective requirements in 10 CFR Part 60.

71.33(a)(5)(iv) — This requirement mentions the description of the package ". . . must include . . . specific materials of construction, weights, dimensions, and fabrication methods of valves, sampling ports . . .." The requirement is uncertain whether it merely provides an inclusive list of items which must be covered if they are used in the WP or whether it mandates the incorporation of such features in the design. If the latter is true, the use of valves and sampling ports, depending on the specific design chosen, could pose a potential for exceeding long-term containment and release rate limits (10 CFR 60.113). Furthermore, such design features are inconsistent with DOE's current preference for a completely sealed MPC.

71.87(b) — This requirement calls for the licensee to determine prior to each shipment that the package ". . . is in unimpaired physical condition except for superficial defects such as marks or dents." The definition of "package" in 10 CFR 71.4 includes the package and its contents. If DOE chooses the option to use an MPC which is welded shut, it is not clear how this requirement could be fully satisfied. In addition, the allowance for superficial marks and dents, which are not a concern for transportation safety, may pose a risk to long-term performance in the disposal phase, especially if DOE takes credit for the MPC as a barrier to HLW release. If WP capability to control HLW release is attributed solely to the disposal overpack in DOE's demonstration of compliance with 10 CFR Part 60 requirements, then damage accumulated by the MPC during storage and transportation may not be significant.

Consistency of requirements concerning poisons to prevent criticality with 10 CFR Part 60 regulations with respect to DOE's plans for the MPC concept.

The general requirements for criticality prevention in 10 CFR Part 71 (for fissile material) focus on specific package design concerns regarding criticality (i.e., use of geometry and neutron moderators), while those in 10 CFR Part 60 are broader in scope and pertain to the occurrence of unlikely events (no mention is made of poisons). Upon initial review, these two approaches to criticality control from a

regulatory standpoint appear to complement each other. However, both requirements should be reviewed in greater depth for technical inconsistencies or problems.

Consistency of requirements concerning structural integrity of internal baskets to support spent fuel assemblies and prevent criticality consistent with 10 CFR Part 60 requirements.

71.53 — It is necessary to determine whether the SNF DOE plans to ship meets any of the exclusion criteria outlined in this requirement. If the exclusions do not apply, then additional criticality criteria in 10 CFR 71.55 must be considered (in addition to 71.57 through 71.61, if applicable). Among the criteria in 10 CFR 71.53 are conditions for criticality calculations and design criteria for compliance with the normal operating tests in 10 CFR 71.71 (including geometric form of package contents not substantially altered, no more than 5 percent reduction in total effective volume of the packaging, and no more than 5 percent reduction in spacing between fissile contents and outer surface of package). Such requirements may not necessarily be inconsistent with 10 CFR Part 60 [i.e., 10 CFR 60.131(b)(7) and 60.135(a)(2)], but they are more specific (and test based) and, therefore, require further analysis.

Other Issues

71.85(a) — This requirement pertains to inspection of the waste packaging prior to the first use for the shipment of material. It states the licensee ". . . shall ascertain that there are no cracks, pinholes, uncontrolled voids, or other defects which could significantly reduce the effectiveness of the packaging." If DOE chooses the option which includes a welded MPC for loading the fuel and different overpacks for transportation, storage, and disposal, then based on the definition of "packaging" in 10 CFR 71.4, the MPC would also have to be inspected in a similar manner.

2.3.1.2 10 CFR Part 72—Licensing Requirements for the Independent Storage of Spent Nuclear Fuel and High-Level Radioactive Waste

Initial consideration of this Part of the regulations was conducted with respect to three considerations as delineated in the following sections:

Requirements which, if met by the applicant in an MPC design, might preclude meeting waste package or EBS performance objective requirements in 10 CFR Part 60.

None identified.

Consistency of requirements concerning poisons to prevent criticality with 10 CFR Part 60 regulations with respect to DOE's plans for the MPC concept.

72.124(b) — This requirement mentions (when practicable) the design of an Independent Spent Fuel Storage Installation (ISFSI) or MRS for criticality control ". . . must be based on favorable geometry, permanently fixed neutron absorbing materials (poisons), or both. Where solid neutron absorbing materials are used, the design shall provide for positive means to verify their continued efficacy." The current DOE preference to control criticality by using both favorable geometry and fixed neutron absorbers combined with their intent to have a sealed MPC (welded) may conflict with the requirement to provide a positive means to verify continued efficacy of such methods.

Consistency of requirements concerning structural integrity of internal baskets to support spent fuel assemblies and prevent criticality with 10 CFR Part 60 requirements.

No inconsistency identified.

2.3.2 Regulatory Guides

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

This guidance (for 10 CFR Parts 50 and 70) appears consistent with the criticality requirements in 10 CFR Parts 71, 72, and 60. This regulatory guide references ANSI N16.9-1975, "Validation of Calculational Methods for Nuclear Criticality Safety," with the clarifying statement that the details of the validation indicated in Section 4.3 of the ANSI document should be provided to demonstrate the adequacy of the safety margins relative to the bias and criticality parameters and to demonstrate that the calculations embrace the range of variables to which the method will be applied. This clarifying statement, in Regulatory Guide 3.58, will also be consistent with 10 CFR Parts 71, 72, and 60.

2.3.2.2 "Standard Format and Content for the Safety Analysis Report for an Independent Spent Fuel Storage Installation or Monitored Retrievable Storage Installation (Dry Storage)," Chapter 3 on Principal Design Criteria, Nuclear Regulatory Commission, Regulatory Guide 3.48, Revision 1, August 1989.

This guidance (for 10 CFR Part 72) appears consistent with requirements in 10 CFR Part 71 and Part 60. While conditions (such as tornados, missile impacts, and ice loading) which are unique to an above-ground storage facility must be considered in the WP design, such considerations do not appear to place unique design constraints on the waste package to the extent that they would interfere with compliance with Part 60 waste disposal regulations.

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

This guidance (for 10 CFR Part 70) appears consistent with requirements in 10 CFR Parts 71, 72, and 60. This regulatory guide references ANSI/ANS-8.17-1984, "Criticality Safety for Handling, Storing, and Transportation of LWR Fuel Outside Reactors," with the clarifying statement that credit for fuel burnup may be taken only when the amount of burnup is confirmed by reactivity measurements that are appropriate for each type of fuel assembly in the environment to which it will be stored. This clarifying statement will also be consistent with 10 CFR Parts 71, 72, and 60.

2.3.2.4 "Standard Format and Content for a Topical Safety Analysis Report for a Spent Fuel Dry Storage Cask," Nuclear Regulatory Commission, Regulatory Guide 3.61, February 1989.

This regulatory guide closely follows the wording of requirements in 10 CFR Part 72 and does not appear to contain text which leads to additional 10 CFR Part 60 compliance concerns which have not already been identified in the review of Part 72. The guide does include a statement regarding "procedures for inspection, tests, and special preparations of the cask necessary to ensure that the cask

is properly loaded, closed, decontaminated to prevent the spread of contamination, and delivered to a transport vehicle in such a condition that subsequent transport will not impair the effectiveness of the cask to perform its required safety function." This, to some extent, addresses the concern (for the storage part of the disposal system) that an MPC may be damaged from handling prior to arrival at a disposal facility and such damage may impact long-term WP performance. However, the criteria for the degree of damage acceptable for transportation and/or storage may be different for disposal. Additional inspection requirements may be needed to provide confidence that MPCs damaged prior to transport to the disposal facility would be identified. Such planned inspections provide added confidence that MPCs damaged prior to transport to the disposal facility would be identified. Nevertheless, since the scope of 10 CFR Part 72 is storage, the phrase "perform its required safety function" in this guidance is likely to pertain only to storage and not necessarily to consideration of disposal safety functions.

If DOE decides to take any credit for the MPC for containment during the disposal phase, they will most likely have to implement some form of package inspection/testing program upon receipt of waste at the repository in order to ensure the packages are functioning as intended. Pertinent requirements in Part 60 are not as specific as those in Part 71 or Part 72, however, 10 CFR 60.73 and 60.74 do provide a basis for the NRC to ensure packages are functioning as designed prior to emplacement (see discussion of 60.73 and 60.74 in Section 2.1.2 for pertinent information).

2.3.2.5 "Standard Format and Content for the Safety Analysis Report for Onsite Storage of Spent Fuel Storage Casks," Chapter 3 on Principal Cask Design Criteria, Nuclear Regulatory Commission, Regulatory Guide 3.62, February 1989.

This regulatory guide includes storage cask design criteria for environmental conditions, some of which are different from those which are a concern for disposal. These include design for tornado and wind loadings, tornado missiles, snow and ice loadings, and combined loads. Designing the WP to comply with such criteria is not likely to negatively affect or preclude compliance with 10 CFR Part 60 requirements.

2.3.2.6 "Standard Format and Content of Part 71 Applications for Approval of Packaging of Type B, Large Quantity, and Fissile Radioactive Material," Nuclear Regulatory Commission, Regulatory Guide 7.9, Revision 1, January 1980.

This guidance (for 10 CFR Part 71) appears consistent with safety regulations in Parts 60 and 72. The information requested, upon initial review, does not appear to constrain the DOE in their WP design in a way which would interfere with compliance with the Part 60 disposal requirements. To the contrary, the specific tests required for normal and accident conditions may help to provide additional assurance in the viability of the package for disposal. Nonetheless, because of the different types of safety concerns involved, DOE must still meet all the WP performance requirements for disposal as well as transportation and storage (even though there will be some overlap and redundancy in the required analyses). Specific design criteria for criticality mentioned.

2.3.2.7 "Establishing Quality Assurance Programs for Packaging Used in the Transport of Radioactive Material," Nuclear Regulatory Commission, Regulatory Guide 7.10, Revision 1, June 1986.

The quality assurance (QA) requirements in 10 CFR Part 60 reference 10 CFR Part 50, Appendix B, whereas Part 71 and Part 72 adopt language from 10 CFR Part 50, Appendix B, with some

changes to reflect the QA needs for each system. While these regulations appear generally consistent from one Part to the other, an inconsistency regarding recordkeeping has been identified which may be a concern for meeting disposal requirements in 10 CFR Part 60. A more detailed review of the three groups of regulations is necessary to identify other potentially important differences which may exist.

The MPC concept will necessitate some level of integration of recordkeeping efforts regarding activities affecting quality among transportation, storage, and disposal systems such that pertinent records will exist to meet disposal QA recordkeeping requirements and other disposal requirements which may call for information on waste package history [e.g., 10 CFR 60.71(b)]. To this end, a potential concern exists regarding differences in the treatment of recordkeeping requirements for each system. The length of time required for recordkeeping of activities affecting quality is treated differently in 10 CFR Part 71, Part 72, and Part 60. The requirements of 10 CFR 71.135 require the licensee to maintain records for 3 years following termination of the activity which the license was granted (i.e., the use of an MPC for transportation of HLW) while 10 CFR 72.174 requires records to be kept until termination of the license (for storage). The requirements in 10 CFR Part 60 (which reference 10 CFR Part 50, Appendix B) allow the licensee to determine the duration of recordkeeping activities. These differences should be assessed for potential conflicts between anticipated record needs for disposal from the two other systems, the time period in which such records would be needed, and the anticipated license termination dates for transportation and storage systems.

3 TECHNICAL CONSIDERATIONS

MPC design concepts and issues which create special problems with respect to compliance with 10 CFR Part 60 are briefly discussed below.

3.1 EARLY DESIGN DECISIONS

Construction of a number of MPCs in accordance with design decisions which may have important performance and regulatory compliance implications will be made very early in the process, prior to submittal of a license application design for the WP for a geologic repository. This subject was previously discussed with respect to 10 CFR Part 60 requirements. Specific MPC design decisions of greatest significance which fall into this category include the choice of materials of construction, design of the closure weldment, surface finish, and selection of manufacturing processes (such as peening, grinding, etc.). A systems approach that addresses all aspects of MPC use [storage, transport, disposal, retrieval (if necessary), and all effects thereof, such as heating] would be beneficial to DOE's design process.

3.2 LARGE, HEAVY WASTE PACKAGES

The large diameter of waste packages which would accommodate the MPC concept would require that underground excavations and ancillary equipment be significantly larger than earlier designs. Portions of the Exploratory Studies Facility which are planned to be incorporated into the GROA design will be excavated during site characterization, so changes in excavation plans must be made early. Design to permit retrieval of large, heavy overpacks has not been shown to be considered by DOE for the MPC concept.

3.3 CRITICALITY AND LONG-TERM PERFORMANCE

Because of the longer time period for postclosure criticality control, the criteria in 10 CFR 60.131(b)(7) may need to be examined further. The NRC raised this as a regulatory uncertainty in SECY-91-225, "Second Update of Regulatory Strategy and Schedules for the High-Level Waste Repository Program" (NRC, 1991).

To keep the probability of criticality very unlikely for the 10,000-year postclosure period, it may be necessary to preclude criticality under "anticipated processes and events" and perhaps under "unanticipated processes and events." It can be argued that the latter criterion is reasonable, since criticality would produce a large localized radiation and thermal pulse and would produce a new inventory of plutonium and fission products, which, it is assumed, would not have been considered in the postclosure performance assessment.

3.3.1 Basket Integrity

Basket integrity may not be an important issue if the SNF is placed in the MPC in its original configuration geometry. Deviations from the original geometry of fuel bundles supported by the basket within the MPC would most likely lessen the likelihood of criticality, because fuel bundles, as removed intact from the reactor storage, are in the optimal geometry for criticality.

3.3.2 Poison Integrity

If poisons are relied upon to prevent criticality, poison integrity will be a consideration because fission product poisons may decay with time, and added poisons may be removed from the intended location by physical damage, removal, or leaching.

3.4 BURNUP CREDIT

DOE initiated a program to assess the inclusion of burnup credit for criticality control compliance with regulations for storage, transport, and disposal of SNF, generated at both pressurized water reactors (PWRs) and boiling water reactors (BWRs). The DOE presented its preliminary plans for consideration of burnup credit in a joint meeting of the DOE and NRC on August 27, 1993 (Milner, 1993).

A program that includes burnup credit for criticality control compliance for disposal of SNF must address several considerations unique to a geologic repository. Some of the major considerations that must be assessed in the allowance of burnup credit being applied to the postclosure aspects of a repository are identified below.

- The NRC needs to resolve the regulatory uncertainty related to postclosure criticality criteria (NRC, 1991). The DOE needs to determine if their considerations for burnup credit are adequate for the long-term postclosure period of time, which allows for significant decay of fission product poisons.

- Considerations of physical changes from that of assumed fresh fuel may include:

  (i) removal of fissionable materials (e.g., ^{234}U)

  (ii) accumulation of fission products that are neutron absorbers

  (iii) accumulation of new fissionable materials (e.g., ^{239}Pu)*

  (iv) decay of fission products that are neutron absorbers*

  (v) decay of new fissionable materials*

  *Note: These items may not have been considered in the NRC/DOE Meeting viewgraphs, see page 15, "Background" (Milner, 1993).

- Methods to accurately assess actual isotope concentrations within a fuel bundle may need to be developed.

  (i) Because there has been some fuel rod consolidation and it has been proposed that individual fuel rods within a fuel bundle may be exchanged at the reactor, assumptions about fuel-rod/fuel-bundle isotope concentrations may need to be reconsidered, and a determination made that accurate isotope concentration mapping is feasible under all possible scenarios.

(ii) Because there have been refinements in fuel bundle isotope mapping methods, which displace earlier assumptions about SNF burnup, more details on trends in mapping/measurement techniques need to be presented.

(iii) Because there will continue to be refinements in fuel bundle isotope mapping methods, which may displace current assumptions about SNF burnup, more details on potential mapping/measurement techniques need to be presented. As better measurement techniques and confirmatory analyses become available, the potential for regulatory noncompliance (based upon current burnup mapping approaches/data) needs to be considered.

(iv) Gross neutron and gross gamma measurements that may be used to determine isotope concentrations may be inadequate, considering the large number of variables such as: (a) initial fuel and cladding constituents, (b) fabrication impurities, (c) full power hours of exposure, (d) neutron flux densities during exposure, (e) time history versus neutron flux density, (f) decay periods, (g) physical dimensions, (h) emission energy spectrum, etc.

- Methods to predict long-term neutron reflection, multiplication, moderation, and absorption within the waste package need to be better assessed. Pertinent factors may include:

  (i) amount of water and other moderators (e.g., beryllium, deuterium, or graphite) present during the postclosure period

  (ii) amount of actinide concentrations in a waste package during the postclosure period

  (iv) amount of heat generated in a waste package during the postclosure period

  (v) amount of selective leaching of poisons from the SNF and the waste package during the postclosure period

- Methods to predict long-term neutron reflection, multiplication, moderation, and absorption in the geologic media needs to be better assessed. Pertinent factors may include:

  (i) amount of water and other moderators (e.g., beryllium, deuterium, or graphite) present during the postclosure period

  (ii) amount of actinide concentrations near a waste package during the postclosure period

  (iii) amount of heat generated near a waste package during the postclosure period

  (iv) amount of selective leaching of poisons from around the waste package during the postclosure period

- Methods to predict long-term geometric changes in the SNF in the geologic repository needs to be better assessed. Pertinent factors may include:

(i) consolidated or original fuel bundle configuration (the original configuration was designed to ensure criticality)

(ii) dissolution and movement of the SNF to a configuration more likely to become a critical mass (a k_{eff} greater than one)

If the surface of the MPC requires decontamination at any time, the effect of decontamination on the MPC surface may affect its long-term performance for containment and gradual release of radionuclides.

3.5 INSPECTION AND TESTING (INCLUDING DAMAGE DETECTION)

Instrumentation and techniques for inspection and testing of the MPC for acceptance at the repository for disposal may require development, and DOE should consider plans for such development. Criteria for acceptance of the WP for disposal have not been developed.

3.6 CONSOLIDATION OF PARTICULATES

The requirement for consolidated waste form is complicated by the particulate form of spent fuel within fuel rods, although the combination of MPC plus overpack could be considered equivalent to a consolidated waste form from the perspective of limiting availability and generation of particulates.

4 AREAS OF CONCERN FOR HLW DISPOSAL—SUMMARY

This section summarizes those areas of concern for determining compliance with HLW disposal requirements from 10 CFR Part 60 for the MPC design concept.

4.1 SEQUENCE OF DESIGN DECISIONS PRIOR TO LICENSE APPLICATION SUBMITTAL

The greatest concern with the MPC design concept is that a number of MPCs would be constructed in accordance with design decisions which have important performance and regulatory compliance implications before a license application design for a WP for a geologic repository is submitted. NRC can only make determinations of compliance with regulatory requirements on these design decisions after the license application for the repository is received. Compliance with design criteria in 10 CFR 60.135 is especially at risk. Specific MPC design decisions of greatest significance which fall into this category include the choice of materials of construction, consideration of galvanic corrosion processes arising from the MPC within its disposal overpack, design of the closure weldment, surface finish, and selection of manufacturing processes (such as peening, grinding, etc.). Site characterization data may be insufficient to evaluate each of the following: (i) interaction of the emplacement environment with the WPs; (ii) assessment of WP performance for containment and gradual release; (iii) interactions of the MPC part of the WP with its environment; (iv) consideration of alternatives to MPC design; (v) and design bases which relate to general performance objectives or to principal design criteria.

4.2 CRITICALITY CONSIDERATIONS

A number of details concerning criticality needs to be further investigated for the MPC design concept. The current DOE preference to control criticality by using both favorable geometry and fixed neutron absorbers combined with their intent to have a sealed MPC (welded) may conflict with the requirement from 10 CFR Part 72 to provide a positive means to verify continued efficacy of such methods. To keep the probability of criticality very unlikely for the 10,000 year postclosure period, it may be necessary to preclude criticality under "anticipated processes and events" and perhaps under "unanticipated processes and events," since criticality would produce a large localized radiation and thermal pulse and would produce a new inventory of plutonium and fission products, which it is assumed would not have been considered in the postclosure performance assessment.

Basket integrity may be an important issue, although it may not be if the SNF is placed in the MPC in its original configuration geometry, since deviations from the original geometry would most likely lessen the likelihood of criticality.

If poisons are relied upon to prevent criticality, poison integrity will be a consideration because fission product poisons (e.g., Xenon-135) may decay with time, and added poisons may be removed from the intended location by physical damage, removal, or leaching. Some of the major considerations that must be assessed in the allowance of burnup credit being applied to the postclosure aspects of a repository are numerous and are identified previously in this report along with considerations concerning burnup.

The requirement in 10 CFR 60.131(b)(7) concerning criticality would appear to encompass any damage to the MPC within transportation and storage overpacks that might affect criticality before or after emplacement at the repository. Burnup and reliance upon installed poisons are not mentioned.

4.3 TESTS AND INSPECTIONS

Instrumentation and techniques for inspection and testing of the MPC for acceptance at the repository for disposal may require development, and DOE should consider plans for such development. Criteria for acceptance of the WP for disposal have not been developed, and the tests which the Commission deems appropriate or necessary are a requirement for the repository license. After the license application for the repository has been submitted, the opportunity to perform certain tests may be lost, since the MPC will be welded shut years before. Specific acceptance criteria for the MPC for disposal at the repository would be needed for free liquids, leak-tightness, and level of damage accumulated during transportation and storage. Technical difficulties include monitoring the condition of MPC internal components, including structural integrity of baskets, location and stability of poisons for criticality control, and structural integrity of the spent fuel.

Tests need to be developed to determine thermal interaction effects of the WP and its emplacement environment for the performance confirmation program. If the thermal loading imposed by an MPC is too great, the HLW within it would need to be redistributed to reduce the thermal load. For the performance confirmation program, DOE will need to devise laboratory experiments "which focus on the internal condition of the waste packages," and inaccessibility of HLW within MPCs would create difficulties in analyzing its behavior and predicting its long-term performance. At question is whether or not to include backfill in the emplacement environment duplicated in the laboratory experiments. 10 CFR Part 71 requires inspection of the waste packaging prior to the first use for the shipment of material, and determination prior to each shipment that the package ". . . is in unimpaired physical condition except for superficial defects such as marks or dents." While requirements in 10 CFR Parts 71 and 72 cover damage to an HLW package during transportation and storage, they are not written to address effects of WP damage on long-term, repository performance.

4.4 RETRIEVABILITY

Consideration of retrievability of very large, heavy emplacement overpacks containing several MPCs without loss of containment has not been shown. If backfill is used, removal by overcoring (as has been anticipated for SCP reference design canisters emplaced in backfilled drifts) would not be practical. Very large, heavy WPs incorporating multiple MPCs in disposal overpacks would likely complicate the design of the underground facility to permit retrieval of waste. Very heavy WPs may affect underground facility performance by potential damage during overpack transit. The potential for very heavy WPs dictates that access ramps to the underground facility be on a gentler slope, since rail would be used instead of rubber-tired vehicles for WP transport. This would result in much greater excavated volume for access ramps than would have been required for much smaller WPs.

The large diameter of WPs, which would accommodate the MPC concept, would require that underground excavations and ancillary equipment be significantly larger than earlier designs.

4.5 RECORDS

DOE will need to begin their program to maintain records required by other parts of 10 CFR Part 60 [such as 60.21(c)(5), 60.71(b), 60.73, and 60.74] before loading the MPCs with HLW and sealing them. This will occur before the license application has been submitted. These records are to include ". . . receipt, handling, and disposition of radioactive waste at a geologic repository operations area . . .." They reference 10 CFR Part 50, Appendix B, whereas Part 71 and Part 72 adopt language from 10 CFR Part 50, Appendix B, with some changes to reflect the QA needs for each system. While the QA requirements in 10 CFR Part 60, Part 71, and Part 72 appear generally consistent, the MPC concept will necessitate some level of integration of recordkeeping. The length of time required for recordkeeping of activities affecting quality is treated differently in 10 CFR Part 71, Part 72, and Part 60.

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