8 CRITICALITY EVALUATION

8.1 Conduct of Review

The review of the criticality analysis included Chapter 3, Principal Design Criteria, and Chapter 4, Installation Design, of the SAR (Private Fuel Storage Limited Liability Company, 2000). Chapter 3 of the SAR describes the design criteria and features of the proposed ISFSI that ensure the spent nuclear fuel stored at the site will remain subcritical. Chapter 4, which describes the installation design, discusses the proposed cask system and the criticality analysis performed for the cask. The objective of the criticality review is to ensure that the stored materials remain subcritical under normal, off-normal, and accident conditions during all operations, transfers, and storage at the proposed PFS Facility. This review considered how the information in the SAR addresses the following regulatory requirements:

- 10 CFR 72.40(a)(13) requires that there is reasonable assurance the proposed activities can be conducted without endangering the health and safety of the public.

- 10 CFR 72.124(a) requires that the proposed ISFSI handling, packaging, transfer, and storage systems for the radioactive materials be designed to be maintained subcritical and that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes must occur in the conditions essential to nuclear criticality safety.

- 10 CFR 72.124(b) requires that, when practicable, the design of the ISFSI be based on favorable geometry, permanently fixed neutron poisons, or both and that the design provide for positive means to verify the continued efficacy of any neutron poisons.

- 10 CFR 72.124 (c) requires that each area, except underwater, where special nuclear material is handled, used, or stored have a criticality monitoring system. Monitoring systems of dry storage areas are not required if the special nuclear material is packaged in its stored configuration under a 10 CFR Part 72 license.

The applicant proposes to use the HI-STORM 100 Cask System, which has been reviewed and approved by the NRC under the general license provision of 10 CFR Part 72. There were no site-specific conditions identified in the PFS Facility SAR that impact the criticality safety of the cask.

8.1.1 Criticality Design Criteria and Features

This section evaluates whether the proposed criticality safety design criteria and features will maintain the stored materials in a subcritical configuration. The Facility design criteria and features are described in SAR Sections 3.3.4, Nuclear Criticality Safety and 3.6, Summary of Design. Section 4.2.1.5.4, Criticality Design, discusses the HI-STORM 100 cask design with respect to criticality safety. The applicant did not rely on the use of burnup credit, burnable neutron absorbers, or fixed neutron absorbers for the criticality safety analysis.

8.1.1.1 Criticality Design Criteria

The applicant described the criticality safety design criterion in SAR Section 3.3.4, Nuclear Criticality Safety. The casks are designed such that at least two unlikely, independent, and concurrent or sequential changes to the conditions essential to criticality safety must occur before an accidental criticality is possible. The design criterion for criticality safety is that the effective multiplication factor, k_{eff} , including statistical biases and uncertainties shall not exceed 0.95 under all credible normal, off-normal, and accident conditions and events. The proposed cask system, the HI-STORM 100, meets this design criterion.

The staff reviewed the proposed design criteria for the Facility. The staff also reviewed the cask design criteria to ensure consistency with the Facility. The staff finds acceptable the proposed design criteria because the material will be stored such that subcriticality is maintained with k_{eff} not to exceed 0.95 for all normal, off-normal and accident conditions and will, therefore, meet the requirements of 10 CFR 72.124(a). The staff also finds that the use of an NRC-certified cask will ensure that the activities at the proposed ISFSI will be performed without endangering the health and safety of the public, in accordance with 10 CFR 72.40(a)(13). The Facility conditions for criticality safety are based upon the acceptance criteria in Section 8 of NUREG-1567 (Nuclear Regulatory Commission, 2000a), such as maintaining k_{eff} $\leq$0.95 for all conditions and no credit for burnup, burnable neutron poisons, or neutron poisons in the cask.

8.1.1.2 Features

The PFS Facility criticality safety design features are described in SAR Section 3.3.4.1, Control Methods for Prevention of Criticality. The proposed cask system, the HI-STORM 100 Cask System, maintains the spent fuel in a subcritical configuration independent of the Facility. The cask design feature relied upon to prevent criticality is the canister geometry, which establishes sufficient fuel assembly separation and is described in Chapter 6 of the HI-STORM 100 FSAR (Holtec International, 2000). All canisters will arrive at the Facility in a dry condition and will not be opened at the Facility. The canisters are transferred to the HI-STORM 100 storage cask which is designed such that there is no credible mechanism to allow water to enter the canister during storage.

The canisters also employ fixed neutron poisons and flux traps, but these are only necessary when the canisters are filled with fresh water (i.e., during fuel loading/unloading at a utility), or to meet the requirements of 10 CFR Part 71 during offsite transportation. For offsite transportation, 10 CFR 71.55(b) requires that spent fuel transportation casks are designed to be subcritical if water were to enter the canister.

Per 10 CFR 72.124(c), a criticality monitoring system is not required because the material is packaged in its stored configuration under a Part 72 license. As stated above, the canisters are not opened at the Facility.

The staff verified that the design features important to criticality safety are clearly identified and adequately described. The staff finds that the design features are based on favorable geometry and therefore meet the requirements of 10 CFR 72.124(b). The staff also finds that the stored material will be maintained in a subcritical configuration; therefore, the design provides reasonable assurance that the activities authorized by the license can be conducted without endangering the health and safety of the public as required by 10 CFR 72.40(a)(13).

8.1.2 Stored Material Specifications

This section of the SER evaluates the description of the stored material specifications used by the applicant to ensure that the spent nuclear fuel stored on the site will be maintained in a subcritical configuration. The proposed stored material specifications are discussed in Section 3.1.1 of the SAR. The materials will consist of the PWR and BWR spent fuel assemblies approved for storage in the HI-STORM 100. The approved contents for the HI-STORM 100 Cask System are given in Appendix B of Certificate of Compliance No. 1014. The proposed Technical Specifications for the PFS Facility specify that the spent nuclear fuel to be stored in at the Facility shall meet the requirements given in Section 2.0 of Appendix B to Certificate of Compliance No. 72-1014.

The staff reviewed the proposed fuel specifications given in the SAR to ensure that they are bounded by the approved contents for the HI-STORM 100 Cask System. The staff finds that the proposed material specifications are adequate to ensure that the contents will be maintained subcritical and that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes must occur in the conditions essential to nuclear criticality safety, in compliance with 10 CFR 72.124(a).

8.1.3 Analytical Means

This section of the SER evaluates the analytical means used by the applicant to show that the spent nuclear fuel stored at the Facility will remain subcritical. Relevant information concerning the HI-STORM 100 Cask System is contained in SAR Section Chapter 4.2.1.5.4, Criticality Design.

8.1.3.1 Model Configuration

The individual cask model configuration was reviewed and approved by the staff during the certification process of the cask and is discussed in the staff's HI-STORM 100 SER. The HI-STORM 100 cask analysis assumed fresh fuel at the maximum allowed enrichments, worst case configuration, and flooding with fresh water at various densities. The analysis also considered a single cask and an array of casks. There were no site-specific conditions that impacted the criticality safety analysis of the cask; therefore, no additional modeling by the applicant was necessary for the Facility.

8.1.3.2 Material Properties

The material properties were reviewed and approved by the staff during the certification process of the HI-STORM 100 Cask System, and is discussed in the staff's HI-STORM 100 SER.

8.1.4 Applicant Criticality Analysis

This section of the SER evaluates whether the applicant addressed the most reactive conditions and whether the computer programs used were appropriate for this system. The error contingency criteria and verification analysis are given in SAR Sections 3.3.4.2 and 3.3.4.3. A synopsis of the HI-STORM 100 criticality analysis is found in SAR Section 4.2.1.5.4, Criticality Design.

8.1.4.1 Computer Program

The computer program used to perform the HI-STORM 100 criticality analysis is described in the HI-STORM 100 FSAR and in the staff's related SER. No additional criticality codes or calculations are necessary for the Facility.

8.1.4.2 Multiplication Factor

Results of the HI-STORM 100 criticality analysis show that k_{eff} of the HI-STORM 100 Cask System will not exceed 0.95 for all allowed fuel loadings under all normal, off-normal, and accident conditions. This meets the design criterion for the Facility. The calculated k_{eff} values were reviewed by the staff during the certification process of the cask and are discussed in the staff's HI-STORM 100 SER. No additional calculations were performed for the Facility.

8.1.4.3 Benchmark Comparisons

SAR Section 3.3.4.3, Verification Analysis, requires benchmark comparisons for any criticality calculations not previously approved by the NRC. No additional calculations are necessary for the Facility as there were no site-specific conditions that affect the criticality safety analysis. The benchmark comparisons used in the HI-STORM 100 analysis were reviewed during the certification process of the cask and are discussed in the staff's HI-STORM 100 SER (Nuclear Regulatory Commission, 2000b,c).

8.1.4.4 Independent Criticality Analysis

No additional criticality calculations are necessary for the Facility; thus no confirmatory calculations were performed.

8.2 Evaluation Findings

Based on a review of the SAR, the staff has determined that:

- The design, procedures, and materials to be stored for the proposed PFS Facility provide reasonable assurance that the activities authorized by the license can be conducted without endangering the health and safety of the public, in compliance with 10 CFR 72.40(a)(13).

- The design and proposed use of the PFS Facility handling, packaging, transfer, and storage systems for the radioactive materials to be stored reasonably ensure that the materials will remain subcritical and that, before a nuclear criticality accident is possible, at least two unlikely, independent, and concurrent or sequential changes must occur in the conditions essential to nuclear criticality safety. The SAR analyses and confirmatory analysis by the NRC adequately show that acceptable margins of safety will be maintained in the nuclear criticality parameters commensurate with uncertainties in the data and methods used in calculations, and demonstrated safety for the handling, packaging, transfer and storage under normal, off-normal, and accident conditions in compliance with 10 CFR 72.124(a) and (b).

- A criticality monitoring system is not required at the PFS Facility since the special nuclear material is packaged in its stored configuration under a 10 CFR Part 72 license, in compliance with 10 CFR 72.124 (c).

8.3 References

Holtec International. 2000. *Final Safety Analysis Report for the Holtec International Storage and Transfer Operation Reinforced Module Cask System (HI-STORM 100 Cask System).* Volumes I and II. HI–2002444. Docket 72-1014. Marlton, NJ: Holtec International.

Nuclear Regulatory Commission. 2000a. *Standard Review Plan for Spent Fuel Dry Storage Facilities*. NUREG–1567. Washington, DC: Nuclear Regulatory Commission.

Nuclear Regulatory Commission. 2000b. 10 CFR Part 72 *Certificate of Compliance No. 1014, Amendment 0, for the HI-STORM 100 Cask System.* Docket No. 72-1014. May 31.

Nuclear Regulatory Commission. 2000c. *Holtec International HI-STORM 100 Cask System Safety Evaluation Report*. Docket No. 72-1014. May.

Private Fuel Storage Limited Liability Company. 2000. *Safety Analysis Report for Private Fuel Storage Facility*. Revision 18. Docket No. 72–22. La Crosse, WI: Private Fuel Storage Limited Liability Company.