REMOVE Section 5.1.1.4 on pages 5-5 to 5-6 of the SER and INSERT:

5.1.1.4 Structural Analysis for Confinement Structures

The staff reviewed the information presented on structural analysis in SAR Section 4.2.1, HI-STORM 100 Cask System. The detailed structural analysis of confinement structures is presented in the HI-STORM 100 FSAR. The staff has previously reviewed this structural analysis and found it acceptable, as documented in the staff's HI-STORM 100 SER. As documented in that SER, the structural analysis shows that the structural integrity of the HI-STORM 100 Cask System is maintained under all credible loads. Based on the results presented in the HI-STORM 100 FSAR, the stresses in the MPC under the most critical load combinations are less than the allowable stresses for the MPC materials.

A discussion of the MPC design relative to the storage requirements of the PFS Facility is in SAR Chapter 4, Facility Design. The PFS Facility SAR provides a summary of the analysis performed in the HI-STORM 100 FSAR. The PFS Facility SAR states that for the following loads and combined loading conditions, the spent fuel canister is shown to be within allowable limits of American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section III (American Society of Mechanical Engineers, 1998) and, therefore, meets the Facility design criteria given in SAR Section 3.2, Structural and Mechanical Safety Criteria:

- Dead loads (D)
- Live loads (L)
- Internal (P_i) and external (P_o) pressure loads
- Temperature gradients (T)
- Deceleration loads (A)
- Design tornado wind loads (W_t)
- Tornado-generated missile loads (M)
- Probable maximum flood loads (F_a)
- Explosion pressure loads (E*)
- Thermal loads due to fire (T*)1
- Lightning

The loading conditions at the Facility are enveloped by the loading conditions considered in the HI-STORM 100 FSAR, except for the seismic loads. A structural analysis was performed for the HI-STORM 100 Cask System considering the PFS Facility site-specific seismic loads (Holtec International, 2001a). The analysis shows that the storage system will withstand the imposed loads and not tipover or slide into contact with an adjacent cask when subjected to the PFS Facility site-specific seismic event. The basis for the conclusions for cask stability under the site-specific load is in Section 5.1.4.4 of this SER. Although the Facility site-specific seismic loads are higher than the seismic loads considered in the HI-STORM 100 FSAR, resulting loads on the MPC and fuel assemblies remain bounded by the loads considered in the HI-STORM 100 FSAR. An evaluation was performed for the HI-STORM 100 Cask System for thermal

loads (Holtec International, 1999, 2001b) which supports the conclusion that the resulting loads on the MPC and fuel assemblies remain bounded by the loads considered in the HI-STORM 100 FSAR. Therefore, the staff's conclusions in its HI-STORM 100 SER with respect to the structural integrity of the MPC are valid for the PFS Facility.

As demonstrated in the HI-STORM 100 FSAR and as documented in the staff's HI-STORM 100 SER, the cask is stable and will not tipover in the event of tornado winds with concurrent impact of the tornado-driven design missile (an automobile) at the top of the storage cask. Additionally, the design of the 36-inch-thick reinforced concrete pad at the Facility is based on the use of concrete with a compressive strength of 3,000-psi (at 28 days), reinforcing steel having 60,000-psi yield strength. Concrete for the PFS Facility storage pad has a lower compressive strength than the 4,200-psi concrete (at 28 days) assumed for the reference target ISFSI pad in the HI-STORM 100 FSAR. Also, the PFS soil foundation for the pad consists of soil and soil-cement layers with properties that are different than the soil foundation considered in the HI-STORM 100 FSAR. Therefore, a PFS site specific analysis was performed (Holtec International, 2001c, d) which concluded that, a non-credible, hypothetical tipover of a HI-STORM 100 storage cask at the PFS Facility would result in a deceleration of less than 45g and lower stresses in the MPC than those evaluated in the HI-STORM 100 FSAR. Therefore, the staff's conclusions in its HI-STORM 100 SER with respect to the structural integrity of the MPC are valid for the PFS Facility.

REMOVE the discussion entitled “Canister Transfer Building” on pages 5-7 to 5-8 of the SER and INSERT:

Canister Transfer Building

As identified in Section 4.7.1 of the SAR, the Canister Transfer Building provides physical protection and shielding of the canisters during transfer from the transportation cask to the storage cask. The Canister Transfer Building consists of the shipping cask loading/unloading bays, canister transfer cells, a 200/25-ton overhead bridge crane, a 150/25-ton semi-gantry crane, crane runway girders and their supports, cask transporter bay, tornado-missile barriers, a low-level waste storage room, radiation shield walls and doors, equipment lay-down areas, storage cask delivery and staging platform, mechanical and electrical equipment areas, personnel offices, and restroom areas. Figure 4.7-1 of the SAR illustrates the layout of the Canister Transfer Building. The SAR provides a design description of the Canister Transfer Building in sufficient detail to support a detailed review and evaluation. Consequently, the requirements of 10 CFR 72.24(a) and (b) have been satisfied.

The Canister Transfer Building is a massive reinforced concrete structure with a slab on grade designed in accordance with American Concrete Institute (ACI) 349-90 (American Concrete Institute, 1989). The ACI 349-90 Code provides the minimum requirements for the design and construction of nuclear safety-related concrete structures and structural elements for nuclear power generating stations. The thicknesses of the slab, wall, and roof members were initially sized based on shielding requirements. The calculated thickness was then checked for penetration resistance to the Spectrum II tornado-driven missiles as identified in Section 3.5.1.4 of NUREG–0800 (Nuclear Regulatory Commission,1981). The thickness was shown to be adequate to resist penetration and damage that would subsequently affect performance of the Canister Transfer Building (Stone & Webster Engineering Corporation, 1998b). The reinforced concrete roof will be supported by structural steel elements, designed in accordance with the allowable stress design method of ANSI/AISC N690–1994 (American National Standards Institute/American Institute of Steel Construction, 1994).

Analyses were presented for the site-specific seismic loading conditions (Stone & Webster Engineering Corporation, 1998 a, b, c). The size and placement of the reinforcing steel were based on the results of the seismic analysis. Beams and columns were sized to provide support under all analyzed loading conditions and combinations (Stone & Webster Engineering Corporation, 1998c, 2001i). Details of the analysis of the Canister Transfer Building are presented in Section 5.1.3.4 of this SER.

Sections 4.7, 4.7.2.1, 5.1.4.7, 5.1.6.5, and 9.2.2 of the SAR provide descriptions of the Canister Transfer Building and associated conduct of operational procedures. Components requiring inspection, testing, and maintenance are identified and adequately described in accordance with 10 CFR 72.122(f). Pre-operational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety.

Design in accordance with ACI 349-90 and ANSI/AISC N690–1994 addresses these topics. Design of the Canister Transfer Building allows for access to all locations and regions in the event of emergencies. The design is an open structure with door ways and access corridors provided in accordance with the requirements of 10 CFR 72.122(g).

The design of the Canister Transfer Building allows for handling and storage of the limited radioactive waste generated at the Facility within the low-level waste storage room in accordance with the requirements of 10 CFR 72.128(a). A waste confinement and management evaluation is contained in Chapter 14 of this SER.

Cask Storage Pads

Information on the cask storage pad design and analysis is given in Section 4.2.3 of the SAR. The cask storage pads are independent structural units constructed of reinforced concrete, designed in accordance with ACI 349-90. Each pad is 30 ft × 67ft × 3 ft and is capable of supporting eight loaded HI-STORM 100 storage casks. Figure 4.2-7 of the SAR shows the general layout of the storage pads. The size of the pad is based on a 15-ft center-to-center spacing of the storage casks in the 30 ft width (transverse direction) and 16-ft center-to-center in the 67 ft length (longitudinal direction) of the cask storage pads. The cask storage pad is a conventional cast-in-place reinforced concrete mat foundation structure. It provides a level and stable surface for placement and storage of the storage casks. The cask storage pad design is based on the maximum loaded weight of a storage cask of 360,000 lb, the weight of the HI-STORM 100 storage cask loaded with either MPC-24 or MPC-68 canisters. The SAR provides a design description of the cask storage pads in sufficient detail to support a detailed review and evaluation. Consequently, the requirements of 10 CFR 72.24(a) and (b) have been satisfied.

Inspection and maintenance operations are identified in Sections 5.1.4.7 and 5.1.6.5 of the SAR with additional details provided in Section 9.2.2 of the SAR. ACI 349–90 (American Concrete Institute, 1989) specifies the inspection requirements during the construction of the cask storage pads. The storage casks are passive systems so the necessary inspection and maintenance include only the temperature monitoring system. Pre-operational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. Description of the cask storage pads and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR 72.122(f). The design of the reinforced concrete pads, a simple slab on grade, provides for access to all locations and allows for access to the storage casks in the event of emergencies. There are no barriers built into the cask storage pads that would prevent access to any location on the pads adjacent to the storage casks. This design allows for emergency capability, as required in 10 CFR 72.122(g). This simple slab on grade concept also incorporates the capability for retrieving the spent nuclear fuel canisters. The cask transporter can drive onto the pad to access any storage cask and transport it back to the Canister Transfer Building. Settlement of the pad has also been taken into account, as

discussed in Section 2.1.6.4 of this SER. The requirements of 10 CFR 72.122(l), therefore, are satisfied.

REMOVE section 5.1.3.4 on pages 5-10 to 5-18 of the SER and INSERT:

5.1.3.4 Structural Analysis for Reinforced Concrete Structures

The staff reviewed the structural analysis for reinforced concrete structures with respect to the regulatory requirements of 10 CFR 72.24(c)(2) and (c)(4), 72.122(b)(1), (b)(2), and (c), and 72.128(a).

The Facility reinforced concrete structures, as described in the SAR (Private Fuel Storage Limited Liability Company, 2001), are designed to meet the requirements of ACI 349-90 (American Concrete Institute, 1989) and will be constructed to ACI 318-95 requirements (American Concrete Institute, 1995). The staff accepts the strength design method, as presented in the ACI 349-90, for concrete structures important to safety. Reinforced concrete structures were designed and analyzed to resist the loads and load combinations specified. Static analysis methods determined forces and moments on the structural members as a result of applied service loading conditions. Dynamic analysis methods determined structural member forces and moments for factored loading conditions where structural components were subjected to seismic or tornado-generated missile impact loads.

The reinforced concrete structures important to safety were analyzed for normal, off-normal, and accident loading conditions. These analyses were carried out to ensure that they would be able to perform their intended safety functions under the extreme environmental and natural phenomena as specified in 10 CFR 72.122(b)(1) and (b)(2) and ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992). The ultimate strength method of analysis is used with the appropriate load factors for the following loads:

- Dead loads (D)
- Live loads (L)
- Soil pressure loads (H)
- Temperature gradients (T)
- Wind loads (W)
- Earthquake loads (E)
- Accident (A) loads including explosion over pressure, drop/tipover, accidental pressurization, fire, and aircraft impact
- Design basis tornado wind loads and tornado-generated missile loads (W_t)
- Probable maximum flood loads (F)
- Lightning

The staff has reviewed the SAR and found that the structural analysis procedures have been identified and are in conformance with standard engineering practice, as described in ACI

349-90 (American Concrete Institute, 1989). The relationship between the design criteria, identified in Chapter 3 of the SAR, and the analysis procedures were established in accordance with the requirements of 10 CFR 72.24(c)(2). The applicable codes and standards used in the analysis of the reinforced concrete structures have also been identified in the SAR, in accordance with the requirements of 10 CFR 72.24(c)(4).

Canister Transfer Building

The staff has reviewed Section 4.7 of the SAR and found that structural analysis of the Canister Transfer Building to mitigate environmental effects has been conducted by PFS. The structural analysis under accident loads is given in Sections 8.2.1.1, 8.2.1.2, and 8.2.2.2 of the SAR. The adequacy of the reinforced concrete structures has been demonstrated by the analysis results given in the SAR, as designed to satisfy the requirements of ACI 349-90 (American Concrete Institute, 1989).

The structural analysis of the Canister Transfer Building is described in Section 4.7.1.5.1 of the SAR. The building structure has been analyzed, and structural elements have been designed for the bounding load cases. Section 4.7.1.5.1 of the SAR provides a detailed discussion associated with determination of the governing load combinations. The original nine load combinations were reduced to the two that control the horizontal and vertical loads on the Canister Transfer Building. The staff concurs with the controlling load combinations, which are as follows:

$U_c > D + L + H + T + E$, and

$U_c > D + L + H + T + W_t$,

where U_c is the minimum available strength of a cross section or member calculated according to the requirements and assumptions of ACI 349-90. The dead loads (D) for the Canister Transfer Building include the self weight of the structure and all permanently attached equipment. Live loads (L) include snow and ice loads, bridge and semi-gantry crane loads, normal crane handling loads, normal wind loads, vehicle loads, and equipment loads. For the shallow foundation design considered here, the soil pressure loads (H) are insignificant. To accommodate thermally induced movements, expansion joints will be provided based on the site-specific extreme temperatures (T).

The horizontal loading is controlled by the earthquake (E) and tornado wind (W_t) loading. For the tornado wind loads, the lateral force is proportional to the velocity of the wind squared. Therefore, the load due to 240 mph tornado wind ($\propto 240^2 \Rightarrow \propto 57,600$) is significantly greater than that due to the 90 mph normal wind including the load factors ($\propto 0.75 \times 1.7 \times 90^2 \Rightarrow \propto 10,328$). For out of plane pressures, the tornado wind velocity and associated pressure drop result in a maximum pressure of 319 psf, based on the procedures of ASCE 7–95. Based on PFS's lumped mass model results for the Canister Transfer Building, the peak horizontal

acceleration at elevated locations is bounded by 0.9 g. Assuming 0.9 g horizontal acceleration to account for the acceleration level at elevated locations, the equivalent pressure of 270 psf. Although the tornado pressure is higher, the resulting shear in the wall due to seismic load will be higher because of the inclusion of the full weight of the Canister Transfer Building times the peak ground acceleration in the seismic load. For the wind loading, the shear is proportional to the dynamic pressure times the cross-sectional area of the Canister Transfer Building. When compared on this global basis, the lateral force due to the tornado wind is 4,658 kips versus 36,500 kips for the earthquake, excluding the force due to acceleration of the base mat. Therefore, the design of the Canister Transfer Building's structural elements for resisting horizontal loads is controlled by the earthquake loading.

The vertical loading of the Canister Transfer Building is also controlled by the earthquake loading. For a vertical acceleration of 0.9 g at the roof structure, the resulting uniform load is 335 psf. The 0.9 g is based on response of the roof node of the lumped mass model of the Canister Transfer Building under seismic loading. This uniform pressure load is greater than the uniform load combination specified in ANSI/ANS 57.9 and ACI 349-90, which is 1.4 times the dead load and 1.7 times the live load or 295 psf. Therefore, the design of the Canister Transfer Building structural elements to resist vertical loads is controlled by the earthquake loading.

The staff concurs with the methods used to identify the controlling load combinations. The overall design of the reinforced concrete members is, therefore, appropriately based on the earthquake event.

Analysis of the reinforced concrete Canister Transfer Building has been provided (Stone & Webster Engineering Corporation, 2001m, 1998b,c). A 3-dimensional finite element model, using ANSYS was developed that adequately represents the structural elements of the Canister Transfer Building. Using the controlling load combinations, a finite element analysis identified shear and axial forces and moments in the structural elements of the Canister Transfer Building. Steel reinforcement size and placement for the foundation pad, wall, roof, beam, and column elements were established (Stone & Webster Engineering Corporation, 1998c) based on these demands. The design of the concrete structure and its reinforcement are based on the requirements in ACI 349-90. The ACI 349-90 Code specifies the minimum requirements for the design and construction of nuclear safety-related concrete structures and structural elements for nuclear power generating stations. The procedures for selection of the reinforcement and checks for axial, shear, moment, and torsional resistance of the elements are in conformance with standard engineering practice, as described in ACI 349-90 (American Concrete Institute, 1989). As noted, this analysis is not a final design and covers only major elements under the two seismic loading conditions that are considered by the staff to be bounding. Results of the analysis for these two bounding load cases indicate that the available design strength exceeds that required for the factored design loads (Stone & Webster Engineering Corporation, 1998c). The structural analysis performed by PFS demonstrates that the structural elements of the Canister Transfer Building are designed to resist the seismic

loads based on the site characteristics and environmental conditions, in accordance with the requirements of 10 CFR 72.122(b)(1). PFS's analysis of the stability of the subsurface materials under the Canister Transfer Building loading is evaluated in Section 2.1.6.4 of this SER.

A seismic analysis of the structure was performed to determine the seismic loads for the building design and to generate in-structure response spectra for the design of the overhead and semi-gantry cranes supported by the Canister Transfer Building walls (Stone & Webster Engineering Corporation, 2001m). The seismic analysis was performed following the guidelines of ASCE 4-86 (American Society of Civil Engineers, 1986). ASCE 4-86 provides minimum requirements and indicates acceptable methods for the seismic analysis of safety-related structures of a nuclear facility. The analysis presented in the SAR and supplemental documentation, such as Stone & Webster Engineering Corporation calculations SC-3, SC-4, SC-5, SC-6, and S-10, are based on the site-specific design earthquake anchored at 0.711 g horizontal and 0.695 g vertical (developed from the PSHA). Details of the development of the artificial time histories were based on a near-source recording of a normal-faulting earthquake at Irpinia, Italy (Geomatrix Consultants Inc., 2001b). These time histories were then scaled to the 2,000-yr return period design response spectra using both frequency and time domain approaches. The resulting time histories were shown to satisfy the requirements of Section 3.7.1 of NUREG–0800 (Nuclear Regulatory Commission, 1989) and ASCE 4-86 (American Society of Civil Engineers, 1986) in terms of the statistical independence of the time histories, envelopment of the shock spectra, and the power spectral density levels. The analysis is documented in Calculation 05996.02-G(PO18)-3 (Geomatrix Consultants, Inc., 2001b).

The dynamic analysis is based on a lumped mass model of the Canister Transfer Building with ten mass locations. These included the basemat, the lower roof, the crane elevation, the upper roof, the local flexibility of the walls supporting the crane, and the local flexibility of the roof in the vertical direction. The mass and stiffness properties of the building were based on hand calculations and represent an ideal case where no rotation is present. The lumped mass model is an acceptable model of the Canister Transfer Building. Impedance functions were developed to represent the subgrade, using the layered dynamic soil properties described in Calculation G(P018)-2 (Stone & Webster Engineering Corporation, 2001b) and SC-4 (Stone & Webster Engineering Corporation, 2001a). Discussions of the soil characteristics are contained in Chapter 2 of this SER. These soil characteristics were subsequently used in the seismic analysis of the Canister Transfer Building (Stone & Webster Engineering Corporation, 2001m).

Two seismic load cases were considered. One included 100 percent of the vertical component combined with 40 percent of each horizontal direction. The second included 100 percent of the east-west horizontal direction combined with 40 percent in the north-south horizontal direction and 40 percent of the vertical direction. These load conditions represent the bounding cases for all possible combinations of seismic components. Peak broadened response spectra at elevations 100 and 170 ft were developed for three mutually perpendicular directions of the Canister Transfer Building (Stone & Webster Engineering Corporation, 2001m). For the

north-south direction, the elevated portion of the response spectra, where the response acceleration exceeds the peak ground acceleration, was between 3.5-5.5 Hz. For the east-west direction, the elevated portion of the response spectra was between 2.5-5.1 Hz. In the vertical direction, the elevated portion of the response spectra was between 5–12 Hz. The elevated portions of the response spectra correspond to the natural frequencies of the system. These elevated response levels were used to define the loading in the subsequent three-dimensional equivalent static finite element analysis of the Canister Transfer Building.

Additional seismic (equivalent static) analysis of the Canister Transfer Building, using the conceptual configuration of the building, was performed by the applicant using a three-dimensional ANSYS finite element model of the building and soil below and around the building (Stone & Webster Engineering Corporation, 1998a). The soil is modeled with three-dimensional elastic solid elements, which were assigned properties identified in Chapter 2 of the SAR. The building basemat, walls, and roof were modeled as a grid of 5 x 5-ft shell elements. Elastic beam elements were modeled to represent the beams and columns. The ANSYS model of the Canister Transfer Building is an acceptable representation of the structure and the supporting soil. The basemat was coupled to the soil using gap elements that allow uplift of the foundation. Calculations using two bounding seismic load conditions were performed. As identified in the analysis report (Stone & Webster Engineering Corporation, 1998b), these load conditions were considered by PFS to be the bounding conditions. The staff concurred with these bounding load conditions in the PFS SER, based on its review of the PFS analysis. For each of these cases, an equivalent static analysis was performed based on the zero period accelerations obtained in the seismic analysis described previously (Stone & Webster Engineering Corporation, 1998a). The structural analysis was used to calculate loads on the Canister Transfer Building structural elements. Maximum loads were identified for all structural elements. Rebar size and placement were selected to ensure that the capacity of all sections exceeded the loads. The selected rebar sizes are based on the analysis results with a small factored increase. This modeling process provided a good indication of the overall response of the structure. The Canister Transfer Building reinforcement was designed to meet the minimum flexural and shear reinforcement requirements of ACI 349-90 (American Concrete Institute, 1989). In the SER of September 2000, the staff concluded that the structural analysis carried out by PFS, based on its previous design configuration, demonstrated that the Canister Transfer Building is designed to withstand the effects of natural phenomena, such as earthquakes, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

The applicant plans to revise the detailed analysis and design of the conceptual design configuration it had submitted (Stone & Webster Engineering Corporation. 1998a, b) to account for recent changes in the configuration of the building, using the methods and codes previously approved by the staff (Section 4.7.1.5.3 of the PFS SAR). The applicant states that the changes in the design configuration would not result in changes in the sizes of various structural elements, but would be limited to the amount and placement of reinforcing steel only.

As stated in the staff's SER of September 2000, the Canister Transfer Building is also designed to withstand the loads due to tornado wind and pressure drop by means of its static strength without the need to resort to venting of the structure. In addition, the components representing the external boundary of the Canister Transfer Building have sufficient strength and stability to prevent penetration of the tornado missile and spalling of the concrete face interior to the point of impact, as shown in the calculation package SC-7 (Stone & Webster Engineering Corporation, 1998b). As identified in Section 4.7.1 of the SAR, the design of the Canister Transfer Building will be in accordance with the requirements of ACI 349-90. Since the tornado loads have not changed since issuance of the staff's SER, the staff concludes that the Canister Transfer Building would continue to perform its safety functions during a tornado event.

The Canister Transfer Building, which is approximately 90 ft tall, is identified as a moderate to severe risk factor for possible lightning strike. The Canister Transfer Building will be designed with lightning protection features in accordance with NFPA 780 (National Fire Protection Association, 1997b). This includes multiple air terminals on the roof with a two-way path to ground for any of the terminals. Because of the massive structure of the Canister Transfer Building, potential of structural damage due to lightning strike is minimal. The Canister Transfer Building is designed to withstand the effects of natural phenomena, such as lightning, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

The Canister Transfer Building will not be subjected to flood loads. The location of the Canister Transfer Building is above the maximum probable flood level. In addition, the area will be protected by an earthen berm to prevent sheet flow around the Canister Transfer Building.

The staff has reviewed Section 4.7.3.5.1 (G) of the SAR and determined that the design of reinforced concrete structures, systems, and components provides fire and explosion protection while Section 8.2.5.2 of the SAR shows the capability of structures, systems, and components important to safety to withstand postulated fire and explosion accidents. The Canister Transfer Building is a massive reinforced concrete structure. The proposed Facility would be located on an open gravel surface. PFS will be planting a 300 ft wide crested wheatgrass barrier around the restricted area. Therefore, the site will have more than 100 ft of fuel break around any storage cask or site structure important to safety. Consequently, the Canister Transfer Building will not be affected from any credible wildfire. Potential fires in the Canister Transfer Building are based on 50 and 300 gal. of diesel fuel. The extent and duration of fires are such that the capacity of the structural elements will not be degraded as a result of exposure to fire. As identified in the design criteria, the 1 psi overpressure from explosion is bounded by the pressure drop and stress caused by tornado wind and seismic loading, respectively. The design of the reinforced concrete structure has been shown to be acceptable under these greater load conditions. Therefore, the analysis demonstrates that the Canister Transfer Building is designed to continue performing its safety-related functions effectively under credible fire and explosion conditions, in accordance with the requirements of 10 CFR

72.122(c). Additional discussions on fire and explosion are contained in Section 6.1.5 and Chapter 15 of this SER.

The structural analysis also demonstrates that the Canister Transfer Building is designed such that the waste handling system has adequate safety under normal, off-normal, and accident conditions in accordance with the requirements of 10 CFR 72.128(a) because it is completely housed within the Canister Transfer Building.

In sum, the structural integrity of the Canister Transfer Building has been demonstrated under these normal, off-normal, and accident conditions.

Cask Storage Pads

Based on the information presented in SAR Section 4.2.3.5.1, Storage Pad Analysis, the reinforced concrete pads were designed and analyzed in accordance with ACI 349-90 (American Concrete Institute, 1989) and ANSI/ANS-57.9 (American National Standards Institute/American Nuclear Society, 1992). The ACI 349-90 Code specifies the minimum requirements for the design and construction of nuclear safety-related concrete structures and structural elements for nuclear power generating stations. Based on a review of the storage pad analysis and design calculation package (International Civil Engineering Consultant, Inc., 2000), it was noted that the concrete strength was identified as 3,000 psi. The cask transporter weight was identified as 145,000 lb, whereas in Section 8.2.6 of the SAR it is identified as 160,000 to 185,000 lb. The increased weight of the cask transporter, up to 40,000 lb, is minor when compared with the overall weight of the eight casks (2,880,000 lb). The static and dynamic analyses for evaluating the concrete pad response displacements and internal stresses have used the finite element analysis computer programs CECSAP and SASSI respectively (International Civil Engineering Consultants, Inc., 1996, 1997).

The storage pad analysis and design calculation package (International Civil Engineering Consultants, Inc., 2001) includes static analysis with both dead and live loads using CECSAP (International Civil Engineering Consultants, Inc., 1996). The storage pad was modeled using a three-dimensional, flat-shell finite element model. Gross uncracked stiffness of the storage pad was used for the model. Vertical springs were used to model the upper, best, and lower bounds of the soil support of the pads for the long-term static load conditions. The cask pad analysis is based on the maximum loaded cask weighing 360,000 lb. Three loading patterns of 2, 4, and 8 fully loaded casks are considered. In addition, another load case considered 7 loaded casks and one cask being lifted by a cask transporter on the pad. A dynamic amplification factor of 2 is used for this case to account for any dynamic effect of transporting the cask. Cask loadings are lumped to four points on the outer circular perimeter of each cask. Based on a review of the input files for the static analysis, values for the geometry, soil parameters, and loading are consistent with the design.

Static analysis of the stability of subsurface materials under the storage pad loading (including the casks) is reviewed in Section 2.1.6.4, Stability of Subsurface Materials, of this SER.

The results of the static pad analysis for dead and live loads of cask weights are summarized in Table 4.2-7 of the SAR. Based on the results of this analysis, the cask-loading pattern that produces the highest pad internal stresses is that of four casks on the pad. The maximum moment in the longitudinal direction was $-M_{yy}$ = 109 k-ft/ft and $+M_{yy}$ = 138 k-ft/ft. The corresponding capacities identified in Section 4.2.3.5.2 of the SAR are $-M_{yy}$ = 210 k-ft/ft and $+M_{yy}$ = 218 k-ft/ft. The moment and shear capacities of the reinforced concrete pads are calculated based on the procedures identified in ACI 349–90. The maximum shear force was 19 k/ft (beam) and 9 k/ft (punching). The corresponding ultimate static beam shear capacity identified in Section 4.2.3.5.2 of the SAR is 110 k/ft and an ultimate static punching shear capacity of 110 k/ft. The staff has reviewed the procedures used to determine the ultimate static moment and shear capacity calculation for the reinforced concrete slab and found them to be consistent with industry practice, as identified in ACI 349–90. The checks for normal loading conditions were correctly based on the load combination (1.4D + 1.7L + 1.7H) for demand and the strength reduction factor (0.90 for bending and 0.85 for shear) for capacity. Therefore, considering the static pad analysis, the staff concludes that the storage pad, as designed, provides adequate strength for accommodating the design loading conditions.

The worst-case loading that produces the largest soil bearing pressures is from7 casks plus one cask being carried by the transporter. The maximum soil pressure has been calculated to be 3.6 ksf, which is less than the minimum allowable soil bearing pressure for static loads of 4.36 ksf. Based on a uniform distribution of load (dead weight for the slab and live loads for the casks and transporter) and the appropriate load combination, the staff has calculated the stress in the soil to be equal to 3.6 ksf.

Dynamic analysis (International Civil Engineering Consultants, Inc., 2001) has been performed for the site-specific PSHA design basis earthquake (0.711 g horizontal in two directions and 0.695 g vertical) using both CECSAP and SASSI computer codes. Three component time histories (loads representative of the site-specific design basis earthquake) were applied to the model. The modeling procedures used for the static analysis were also used for this dynamic analysis. For the short-term design basis earthquake loading, three-component boundary springs and dashpots representing the dynamic soil stiffness and radial damping characteristics are used. Values ranging from 0.2 to 0.8 were used to account for variations in the coefficient of friction between the pad and concrete casks. The value of 0.2 represents the upper-bound for sliding displacements of the cask. The value of 0.8 represents the upper-bound estimate of the cask dynamic forces acting on the pad. These values bound the range of frictional coefficient for concrete to steel interfaces. Three loading patterns of 2, 4, and 8 fully loaded casks were considered. The loads cover the range that can be expected at the PFS Facility.

The results of the dynamic pad analysis are summarized in Table 4.2-8 of the SAR. Based on the results of this analysis, the cask-loading pattern that produces the highest pad internal

stresses is that of eight casks on the pad. The maximum moment in the longitudinal direction is $-M_{yy}$ = 203 k-ft/ft and $+M_{yy}$ = 113 k-ft/ft. The corresponding capacities identified in Section 4.2.3.5.2 of the SAR are $-M_{yy}$ = 232 k-ft/ft and $+M_{yy}$ = 242 k-ft/ft. Again the moment and shear capacities of the reinforced concrete pads are calculated based on the procedures identified in ACI 349–90. The maximum moment in the transverse direction is $-M_{yy}$ = 218 k-ft/ft and $+M_{yy}$ = 133 k-ft/ft. The corresponding capacities identified in Section 4.2.3.5.2 of the SAR are $-M_{yy}$ = 225 k-ft/ft and $+M_{yy}$ = 133 k-ft/ft. The maximum beam shear force is 58 k/ft, and the maximum punching shear force is 98 k/ft. The corresponding capacities identified in Section 4.2.3.5.2 of the SAR are 121 k/ft for both shear forces. The staff has reviewed the procedures used to determine the moment and shear capacity calculation for the reinforced concrete slab and found them consistent with industry practice, as specified in ACI 349-90. The checks for dynamic loading conditions were correctly based on the load combination (D + L + H + E) for demand and the strength reduction factor (0.90 for bending and 1.1 × 0.85 for shear) for the capacity. Therefore, considering the dynamic pad analysis, the staff concludes that the storage pad as designed provides adequate strength for accommodating the site-specific seismic loading conditions.

Dynamic analysis of the stability of subsurface materials under the storage pad loading is reviewed in Section 2.1.6.4, Stability of Surface Materials, of this SER. The maximum dynamic soil pressure has been calculated to be 7.35 ksf, which is less than the minimum ultimate soil bearing pressure of 13.1 ksf.

These static and dynamic analyses confirm the structural adequacy of the reinforced concrete storage pad for supporting the storage casks when subjected to the design loading conditions. From the static and dynamic analyses, pad responses were obtained and then combined to give the maximum response values in accordance with the applicable load combinations. The combined response values were then used for checking the structural adequacy of the concrete pad and the soil bearing and sliding stabilities. The structural analysis performed by PFS demonstrates that the cask storage pads are adequately designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events in accordance with the requirements of 10 CFR 72.122 (b)(1). Structural analysis carried out by PFS demonstrates that the cask storage pads are designed to withstand the effects of natural phenomena, such as earthquakes, without impairing the capacity to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

For the slab on grade design of the storage pads, the tornado winds will not exert any additional load to the structure. Additionally, the cask storage pad will not be subjected to flood load because the storage pads will be above the maximum probable flood level (Private Fuel Storage Limited Liability Company, 2000). In addition, the area is protected by an earthen berm to prevent sheet flow over the pads. Moreover, lightning strikes will not affect the safety function of the pad because it is grounded. Therefore, the cask storage pads are designed to

withstand the effects of natural phenomena, such as tornadoes, lightning, and floods without impairing the capacity to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

The PFS Facility concrete storage pads are surrounded by an open gravel surface. The gravel surface will be kept free of growth so no combustibles will be present. The distance from the edge of the gravel surface to the storage pads is greater than required to ensure that wildfires on the boundary will not endanger the cask storage pads. Additionally, PFS will be placing a fire barrier around the perimeter of the Facility restricted area. An analysis of potential fires on the cask storage pads due to a rupture of the transporter fuel tank (50 gal. of diesel fuel) has been performed. As evaluated in Chapter 15 of this SER, the fire from 50 gal. of diesel fuel will be of short duration and will not cause damage to the storage pads. The staff has reviewed Sections 4.2.1.5.1(I) and (j), 4.2.2.5.1(I) and (j), 4.7.3.5.1(e), and 4.7.4.5.1(d) of the SAR and determined that the design of the cask storage pads provides fire protection while Sections 8.2.4.2 and 8.2.5.2 of the SAR show the capability of structures, systems, and components important to safety to withstand postulated fire and explosion accidents in accordance with the requirements of 10 CFR 72.122(c).

REMOVE section 5.1.4 on pages 5-18 to 5-30 of the SER and INSERT:

5.1.4 Other Structures, Systems, and Components Important to Safety

This section contains a review of Sections 4.2.1, HI-STORM 100 Cask System; 4.7.1, Seismic Support Struts; Canister Transfer Building Seismic Support Struts Structural Steel Roof Beams; and Transfer Cell Sliding Doors; 4.7.2, Canister Transfer Cranes; and 4.7.3, HI-STORM 100 Transfer Equipment of the SAR. The staff reviewed the discussion on other structures, systems, and components important to safety with respect to the regulatory requirements of 10 CFR 72.120(a), 72.122(a) through (c), (f), and (g), and

5.1.4.1 Description of Other Structures, Systems, and Components Important to Safety

The following structures and components were identified in the SAR as other structures, systems, and components important to safety.

- Storage Cask (QA Category B)
- Transfer cask and associated lifting devices (QA Category B)
- Canister transfer overhead bridge and semi-gantry cranes (QA Category B)
- Seismic support struts (QA Category B)
- Canister Transfer Building Structural Steel Roof Beams (QA Category B)
- Canister Transfer Building Transfer Cell Doors (QA Category B)

The staff reviewed the description of structures, systems, and components important to safety with respect to the regulatory requirements of 10 CFR 72.24(b) and (c)(4), and 72.122(f) and (g).

Storage Cask

As identified in the SAR Section 4.2.1, HI-STORM 100 Cask System, the storage cask is a steel and concrete cylindrical structure that serves as a missile barrier and radiation shield, provides flow paths for natural convective heat transfer and stability for the system, and absorbs energy during non-credible hypothetical tipover accident events. The storage cask is designed to meet ASME Boiler and Pressure Vessel Code, Section III, Subsection NF requirements (American Society of Mechanical Engineers, 1998). Table 4.2-2 and Figure 4.2-3 of the SAR provide a summary of the physical characteristics of the storage cask. A complete design description of the storage cask system is given in the HI-STORM 100 FSAR.

The design criteria, material properties, and structural analysis of the storage cask, based on the generic design base loadings, are contained in Chapter 3 of the FSAR for the HI-STORM 100 Cask System. This cask system has been licensed for these generic design base loadings under Certificate of Compliance 1014. The generic design base loadings specified in the HI-STORM 100 FSAR envelop the PFS Facility site parameters, except for the seismic loadings.

An additional site-specific cask stability analysis has been performed by Holtec International to demonstrate that the storage cask will not tipover, collide, or slide off the storage pad during a PFS Facility site-specific design-basis seismic event (Holtec International, 2001c). Site-specific structural analysis of storage casks is discussed in Section 5.1.4.4 of this SER.

To limit the deceleration loads on the cask due to a vertical drop or a non-mechanistic tipover event, PFS plans to use overpack concrete with a strength of 3,000 psi. This is a reduction from the 4,200 psi design compressive strength of the overpack concrete identified in the HI-STORM 100 FSAR.

The staff has reviewed SAR Section 4.2, Storage Structures, with respect to the description of the storage cask. These descriptions include consideration of inspection, maintenance, and testing. Components requiring inspection and maintenance are identified and operational procedures summarized. Inspection is limited to checks of the air vents to ensure that they are not blocked. This design also allows for emergency access. Spacing of the storage casks on the reinforced concrete pads allows for access to critical locations and regions in the event of emergencies.

Additionally, the staff review of Section 4.2, Storage Structures, of the SAR determined that the design features of the storage cask related to shielding and heat removal capability are appropriately described. A comprehensive shielding evaluation is contained in Chapter 7 of this SER. The design of the storage cask places the spent nuclear fuel in a sealed canister to limit the amount of radioactive waste generated at an ISFSI. A comprehensive waste confinement and management evaluation is contained in Chapter 14 of this SER.

Transfer Cask and Associated Lifting Devices

As identified in Section 4.7.3 of the SAR, the HI-STORM canister transfer equipment consists of a metal transfer cask (HI-TRAC), HI-TRAC lifting trunnions, shipping cask and transfer cask lift yokes, canister downloader, canister lift cleats, and HI-STORM lifting lugs. The HI-TRAC transfer cask, as identified in Section 4.7.3.4.1 of the SAR, is a heavy-walled cylindrical vessel constructed of carbon steel with water for neutron and lead for gamma shielding. The transfer cask provides an internal cylindrical cavity of sufficient size for housing a HI-STORM canister. An access hole through the HI-TRAC top lid is provided to allow lowering or raising the canister between the transfer cask and shipping or storage cask. A bottom lid incorporates two sliding doors that allow opening the HI-TRAC bottom for the canister to pass through. Figure 4.7-2 of the SAR shows the major components of the transfer cask. Table 4.7-1 of the SAR identifies the physical characteristics of the HI-TRAC transfer cask.

The remaining components are grouped as associated lifting devices. Trunnions are located beneath the transfer cask top flange for lifting and vertical handling of the cask. The function of the lifting yokes is to provide a lifting interface between the crane and the shipping cask or transfer cask. The canister downloader is a hoist unit attached to the top of the HI-TRAC

transfer cask used to raise and lower the canister between the HI-TRAC transfer cask and the HI-STORM 100 storage cask or HI-STAR shipping cask in a single-failure proof mode without risk of over lifting the canister. The function of the canister lift cleats is to provide a means to lift the canister. The function of the HI-STORM 100 storage cask lifting lugs is to provide a means of lifting the storage cask.

The description of the transfer cask and associated lifting devices include consideration of inspection, maintenance, and testing in accordance with ANSI N14.6 (American National Standards Institute/American Nuclear Society, 1993) and NUREG-0612 (Nuclear Regulatory Commission, 1980). Components requiring inspection and maintenance are identified, and operational procedures are summarized. Pre-operational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. This design also allows for emergency load carrying capability. Design of the transfer cask and associated lifting devices allows for control of loads in the event of emergencies.

Detailed design descriptions of the transfer cask and associated lifting devices are given in the HI-STORM 100 FSAR (Holtec International, 2000).

Canister Transfer Overhead Bridge and Semi-Gantry Cranes

The staff has reviewed SAR Section 4.7.2, Canister Transfer Cranes. The Canister Transfer Building houses two cranes, a 200/25-ton overhead bridge crane, (Figure 4.7-5 of the SAR), and a 150/25-ton semi-gantry crane, (Figure 4.7-6 of the SAR). As specified in the Technical Specifications, the cranes are single-failure proof and meet the requirements of NUREG-0612 and NUREG-0554 (Nuclear Regulatory Commission, 1979). The cranes are provided for loading and unloading shipping casks on or off the heavy haul tractor/trailers and transferring spent nuclear fuel canisters between the shipping and storage casks. The canister transfer cranes are designed by Ederer Incorporated. Detailed design of the cranes was performed for the crane vendor by Anatech Corporation (Anatech Corporation, 1998a,b). The staff has determined that the SAR description of the canister transfer overhead bridge and semi-gantry cranes satisfies the requirements of 10 CFR 72.24(b) and 72.24(c)(4) because it provides an adequate description of the cranes with special attention to design characteristics.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Pre-operational, startup, and operational tests will be performed in accordance with ASME NOG–1 (American Society of Mechanical Engineers, 1989) to verify the functional operations of structures, systems, and components important to safety. Therefore the descriptions include consideration of inspection, maintenance, and testing as required in 10 CFR 72.122(f). Design of the canister transfer overhead bridge and semi-gantry cranes allows for access to the crane structure in the event of emergencies. The cranes are designed to hold the load during emergencies in compliance with the requirements of ASME NOG–1. The design allows for emergency capability as required in 10 CFR 72.122(g).

Seismic Support Struts

The staff has reviewed SAR Section 4.7.1.4.1, Seismic Support Struts, and SC-10 (Stone & Webster Engineering Corporation, 2001d). The seismic support struts are rigid assemblies that secure the shipping, storage, and transfer casks to the Canister Transfer Building transfer cell walls during canister transfer operations. Figure 4.7-7 of the SAR shows the general layout of the seismic support struts. Details of the position of the struts are provided in SC-10 with an indication of the maximum load at each of the strut locations (Stone & Webster Engineering Corporation, 2001d). The struts ensure that the casks will remain stable and will not topple in the event of an earthquake during the transfer operation. Each cask utilizes two struts that provide restraint in both horizontal directions. The struts consist of a rigid tubular body with threaded eye rods on both ends. Each strut is pinned to a bracket that is secured to the cask and to the Canister Transfer Building cell wall. Details of the column anchor locations for attachment of the struts to the Canister Transfer Building are also provided. Two strut types are identified based on the required length and load carrying demands. As required in the Technical Specifications, the connection between the seismic support struts and the transfer cask, storage cask, and shipping cask must be sufficiently rigid to resist the design basis earthquake motions. Based on the SAR description of the seismic support struts and the applicable condition in the Technical Specifications, the staff has determined that the SAR adequately describes the seismic support struts per 10 CFR 72.24(b) and 72.24(c)(4) because it provides an adequate description of the struts with special attention to design characteristics.

The design of the struts is in accordance with ASME Subsection NF, Component Supports (American Society of Mechanical Engineers, 1998). Section NF-5000 Examination identifies the test and acceptance criteria. Pre-operational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. Therefore, the description of the seismic support struts provided is sufficient to conclude that the struts will perform their design function in the event of a design-basis earthquake. These descriptions include consideration of inspection, maintenance, and testing, as required in 10 CFR 72.122(f). Design of the seismic support will not impede access to all locations and regions in the event of emergencies. Therefore, the design allows for emergency capability, as required in 10 CFR 72.122(g).

Canister Transfer Building Structural Steel Roof Beams

A steel frame supports the vertical roof dead weight, snow, and seismic loads. The roof decking spans are approximately 5 ft, and are supported by 16 inch deep steel beams. The 16 in. deep roof beams span up to 30 ft in the north-south direction to the main roof girders. Five feet deep main roof steel girders spanning 65 ft in the east-west direction carry the vertical roof loads to embedded plates set in the building's concrete walls. Based on a review of the SAR description of the Canister Transfer Building structural steel roof beams, the staff has determined that the SAR will provides an adequate description of the structural steel with special attention to design

characteristics, and adequately describes the Canister Transfer Building structural steel roof beams in accordance with 10 CFR 72.24(b).

The design of the Canister Transfer Building structural steel roof beams is in accordance with ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction, 1994). Therefore, the description of the Canister Transfer Building structural steel roof beams provided in the SAR is sufficient to conclude that the structural steel will perform their design function in the event of a design-basis earthquake. These descriptions include consideration of inspection, maintenance, and testing, as required in 10 CFR 72.122(f). Design of the Canister Transfer Building structural steel roof beams will not impede access to other locations and regions in the event of emergencies. Therefore, the design allows for emergency capability, as required in 10 CFR 72.122(g). The staff therefore concludes that the design of the Canister Transfer Building structural steel roof beams complies with 72.24(c)(4).

Canister Transfer Building Transfer Cell Doors

There are three openings through the wall on the west side of the transfer cells to allow cask transporter access to each transfer cell. These openings are tornado missile protected during canister transfer operations by 1-foot thick rolling doors fabricated from ½ in. steel plate and 11 in. of concrete fill. These doors are designed to withstand tornado generated missiles in addition to satisfying Seismic II/I and radiation shielding requirements. As discussed in the SAR, the structural profiles will provide adequate radiation shielding.

There are three openings through the wall on the east side of the transfer cells to allow to placement of casks in the transfer cells using the Canister Transfer Building cranes. These doors are designed to remain in place during an earthquake event and satisfy radiation shielding requirements. The doors may yield and become non-functional as a result of the design basis earthquake. However, they are designed to remain on their guide tracks and not detrimentally affect safety-related operations or equipment. The doors consist of 3/8 in. steel cover plates, wide flange internal stiffeners, and 4.125 in. polyethylene fill. The exterior dimensions of the doors are 15 ft wide × 30 ft tall. There are nine equally spaced vertical W4 × 13 stiffeners. The nominal door weight per square foot is 50.36 lb/ft^2.

The design of the Canister Transfer Building transfer cell doors is in accordance with ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction, 1994). Description of the transfer cell doors is sufficient to conclude that the doors will perform their design function in the event of a design-basis earthquake. These descriptions include consideration of inspection, maintenance, and testing, as required in 10 CFR 72.122(f). Design of the Canister Transfer Building transfer cells doors will not impede access to other locations and regions in the event of emergencies. Therefore, the design allows for emergency capability, as required in 10 CFR 72.122(g).

Based on the description in the SAR of the Canister Transfer Building transfer cell doors, the staff has determined that an adequate description of the structural steel with special attention to design characteristics has been provided in accordance with the requirements of 10 CFR 72.24(b) and 10 CFR 72.24(c)(4).

5.1.4.2 Design Criteria for Other Structures, Systems, and Components Important to Safety

The design bases for the other structures, systems, and components important to safety are given in the SAR. Table 4.1-1 of the SAR identifies details of the Facility's compliance with the general design criteria of 10 CFR Part 72, Subpart F. The staff reviewed the discussion of design criteria with respect to the regulatory requirements of 10 CFR 72.24(c), 72.120(a), 72.122(b)(1), (b)(2), (c), and (f), and 72.128(a).

Storage Cask

Design criteria for the cask systems are contained in the HI-STORM 100 FSAR. A discussion of the design criteria for the storage cask is given in Section 4.1.3, Design Criteria for Structures, Systems, and Components Important to Safety, of this SER. As identified in Chapter 4 of this SER, the site-specific criteria are enveloped by the design criteria identified in the HI-STORM 100 FSAR with the exception of the seismic loading. Additional site-specific analysis was performed to demonstrate compliance with the seismic design criteria that were not enveloped.

The staff has reviewed SAR Section 4.2.1, HI-STORM 100 Cask System. The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for the storage cask. The design criteria address the site characteristics and environmental conditions under normal operations and under off-normal and accident events. The design criteria include the effects of natural phenomena and cover credible fire and explosion conditions.

Transfer Cask and Associated Lifting Devices

The HI-TRAC transfer cask is designed for all normal, off-normal, and design basis accident loadings during transfer operation to protect the HI-STORM 100 spent nuclear fuel canister from deterioration, provide adequate shielding, and allow the retrieval for the canister under all conditions. The HI-TRAC transfer cask is designed as a special lifting device in accordance with ANSI N14.6–1993 (American National Standard Institute/American Nuclear Society, 1993) and NUREG–0612. Special lifting devices are designed for handling a certain load or loads. In this case, the specific load is the spent nuclear fuel canister. ANSI N14.6–1993 sets forth the requirements for design, fabrication, testing, maintenance, and QA programs for special lifting devices used to handle containers with radioactive materials. The HI-TRAC transfer cask with transfer lid attached, is designed to meet Level A Subsection NF (American Society of Mechanical Engineers, 1998) stress limits while handling the dead load of the heaviest loaded canister.

The HI-TRAC transfer cask lifting trunnions, lift yokes, canister downloader, canister lift cleats, and storage cask lifting lugs are designed as special lifting devices in accordance with ANSI N14.6-1993 (American National Standard Institute/American Nuclear Society, 1993) and NUREG–0612 for non-redundant special lifting devices. Specifics of the design basis for these components are given in Section 4.7.5.3 of the SAR.

A complete discussion of the design criteria for the transfer cask and associated lifting devices is given in Section 4.1.3, Design Criteria for Structures, Systems, and Components Important to Safety, of this SER. The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety. The design criteria address the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events. The design criteria include the effects of natural phenomena and cover credible fire and explosion.

Canister Transfer Overhead Bridge and Semi-Gantry Cranes

As identified in SAR Section 4.7.2.1, Design Specifications, the canister transfer cranes are designed to meet the requirements of the design criteria contained in Chapter 3, which requires the cranes be designed in accordance with ASME NOG-1 (American Society of Mechanical Engineers, 1989) and be single-failure-proof in accordance with NUREG-0612 and NUREG–0554. ASME NOG–1 covers electric overhead and gantry multiple girder cranes with top running bridges and trolleys used at nuclear facilities, and components of cranes at nuclear facilities. Specifically, the cranes are designated as Type 1 because they are used to handle a critical load and should be designed and constructed so that they will remain in place and support the critical load during and after a seismic event. The cranes do not have to be operational after this event. Single-failure-proof features must be included so that any credible failure of a single component will not result in loss of capability to stop and hold the critical load

within acceptable excursion limits. A complete discussion of the design criteria for the canister transfer overhead bridge and semi-gantry cranes is given in Section 4.1.3, Design Criteria for Structures, Systems, and Components Important to Safety, of this SER. The design criteria for the canister transfer overhead bridge and semi-gantry cranes are described in sufficient detail to support the findings in 10 CFR 72.40 as required by 10 CFR 72.24(c)(1). The applicable codes and standards for the canister transfer overhead bridge and semi-gantry cranes are identified and, therefore, support the findings in 10 CFR 72.40 as required by 10 CFR 72.24(c)(4).

Sections NOG-4000, Requirements for Structural Components, NOG–5000, Mechanical, and NOG–6000, Electrical Components of ASME NOG–1, identify specific design criteria. The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety in accordance with the requirements of 10 CFR 72.120(a). As identified in Chapter 4 of the SER, the design criteria address the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events.   The design criteria include the effects of natural phenomena and cover credible fire and explosion conditions. Performance of testing, inspection, and maintenance activities on the cranes in accordance with 10 CFR 72.122(f) is covered in Section NOG–7000, Inspection and Testing, of ASME NOG–1.

Seismic Support Struts

The support struts are procured as standard sway strut assemblies that conform to ASME Subsection NF requirements (American Society of Mechanical Engineers, 1998) for Class 2 nuclear grade supports (Private Fuel Storage Limited Liability Company, 2001, Section 4.7.1.4.1). Design criteria are identified in Chapter 3 of the SAR and in ASME Subsection NF (American Society of Mechanical Engineers, 1998). The design of the column anchorage is based on ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction,1994). ANSI/AISC N690 is the specification and commentary for the design, fabrication, and erection of structural steel for steel safety-related structures for nuclear facilities. The design criteria for the seismic support struts are described in sufficient detail to support the findings in 10 CFR 72.40 in accordance with the requirements of 10 CFR 72.24(c)(1). The applicable codes and standards for the seismic support struts are identified and, therefore, support the findings in 10 CFR 72.40 as required by 10 CFR 72.24(c)(4). A complete discussion of the design criteria for the seismic support struts is given in Section 4.1.3, Design Criteria for Structures, Systems, and Components Important to Safety, of this SER.

The design of the struts are in accordance with ASME Subsection NF, Component Supports. Section NF-5000, Examination, identifies the test and acceptance criteria. The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance

requirements for the seismic struts. The design criteria address the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, include the effects of natural phenomena, and cover credible fire and explosion conditions.

Canister Transfer Building Structural Steel Roof Beams

Design criteria for the Canister Transfer Building are identified in Chapter 3 of the SAR. The design is based on ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction,1994). The design criteria for the Canister Transfer Building structural steel roof beams are described in sufficient detail to support the findings in 10 CFR 72.40 in accordance with the requirements of 10 CFR 72.24(c)(1). The applicable codes and standards for the Canister Transfer Building structural steel roof beams are identified and, therefore, support the findings in 10 CFR 72.40 as required by 10 CFR 72.24(c)(4). The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for the Canister Transfer Building structural steel roof beams. The design criteria address the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, include the effects of natural phenomena, and cover credible fire and explosion conditions.

Canister Transfer Building Transfer Cell Doors

Design criteria for the Canister Transfer Building are identified in Chapter 3 of the SAR. The applicable loads and load combinations for the transfer cell doors were obtained from Chapter 3 of the PFS Facility SAR. The design acceleration values are identified for the top of the Canister Transfer mat foundation as 1.1 g north-south horizontal, 4.0 g east-west horizontal, and 0.8 g vertical (Stone & Webster Engineering Corporation, 2001m). The governing design load combinations as identified in Section 3.2.11.4 of the PFS Facility SAR:

$1.6S > D + E$
$1.4S_v > D + E$

Allowable stresses for the steel members are based on ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction,1994). The design criteria for the Canister Transfer Building transfer cell doors are described in sufficient detail to support the findings in 10 CFR 72.40 in accordance with the requirements of 10 CFR 72.24(c)(1). The applicable codes and standards for the Canister Transfer Building transfer cell doors are identified and, therefore, support the findings in 10 CFR 72.40 as required by 10 CFR 72.24(c)(4). The design criteria establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for the Canister Transfer Building transfer cell doors. The design criteria address the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, include the effects of natural phenomena, and cover credible fire and explosion conditions.

5.1.4.3 Material Properties for Other Structures, Systems, and Components Important to Safety

The staff reviewed the material properties for other structures, systems, and components important to safety with respect to the regulatory requirements of 10 CFR 72.24(c)(3) and (4).

Storage Cask

The material properties of the storage casks are provided in the HI-STORM 100 FSAR. The staff's evaluation of the HI-STORM 100 FSAR is documented in NRC's HI-STORM 100 SER. As identified in the PFS Facility SAR, PFS will use concrete with a compressive strength of 3,000 psi for the storage cask overpack, instead of 4,200 psi identified in HI-STORM 100 storage cask FSAR. This change is to provide energy absorption in the event of a tipover or handling accident.

Transfer Cask and Associated Lifting Devices

Material properties for the HI-TRAC transfer cask and associated lifting devices are provided in the HI-STORM 100 FSAR. The staff's evaluation of the HI-STORM 100 FSAR is documented in NRC's HI-STORM 100 SER.

Canister Transfer Overhead Bridge and Semi-Gantry Cranes

Information on the materials used in the construction of the cranes is contained in seismic qualification analysis reports for the cranes (Anatech Corporation 1998a,b). This conclusion is based on meeting the material requirements of ASME NOG–1, where the materials are identified. The applicable codes and standards are identified in accordance with the requirements of 10 CFR 72.24(c)(4).

Seismic Support Struts

The seismic support struts are designed in accordance with ASME Subsection NF (American Society of Mechanical Engineers, 1998) requirements for Class 2 nuclear grade supports. This ensures that appropriate materials are used for the seismic support struts. Therefore, the requirements of 10 CFR 72.24(c)(3) are satisfied. The applicable codes and standards are identified in accordance with the requirements of 10 CFR 72.24(c)(4).

Canister Transfer Building Structural Steel Roof Beams

As identified in SC-12 the majority of the structural steel members will be fabricated from steel with a yield strength of 50 ksi. Based on the size of the various elements any one of a number of ASTM designated steels could be used to fabricate the structural elements (American Institute of Steel Construction, 1989). Allowable stresses for the steel members were obtained

from ANSI/AISC N-690. This ensures that appropriate materials are used for the Canister Transfer Building structural steel roof beams. Therefore, the requirements of 10 CFR 72.24(c)(3) are satisfied. The applicable codes and standards are identified in accordance with the requirements of 10 CFR 72.24(c)(4).

Canister Transfer Building Transfer Cell Doors

As identified in SC-14 the structural steel members for the east doors will be fabricated from steel with a yield strength of 50 ksi. The structural steel members for the west tornado resistant doors will be fabricated from steel with a yield strength of 36 ksi. The density of the polyethylene used is 57.4 lb/ft^3. Based on the review of the material properties of the doors, the staff concludes that the requirements of 10 CFR 72.24(c)(3) are satisfied. The applicable codes and standards are identified in accordance with the requirements of 10 CFR 72.24(c)(4)

5.1.4.4 Structural Analysis for Other Structures, Systems, and Components Important to Safety

The staff has reviewed the SAR and found that the structural analysis procedures have been identified and are in conformance with standard engineering practice. Other structures, systems, and components important to safety were designed and analyzed to resist the loads and loading combinations specified in the design criteria. As identified in Sections 4.7.3.5.1 and 4.7.4.5.1 of the SAR, the analyses of other structures, systems, and components important to safety included loading conditions of dead and live loads, thermal loads, earthquake, and fire. Evaluation for tornado, wind, or tornado missiles is not required for structures, systems, and components inside the Canister Transfer Building, except for the transfer cell doors that are identified as part of the tornado missile boundary. The staff reviewed the structural analysis for other structures, systems, and components important to safety, including the transfer cell doors, that are identified as part of the tornado missile boundary, with respect to the regulatory requirements of 10 CFR 72.24 and 72.122.

Storage Cask

The staff has reviewed Section 4.2 of the SAR and found that the design of storage casks to mitigate environmental effects is identified and that Chapter 8 and Sections 8.2.1.1, 8.2.1.2, and 8.2.2.2 of the SAR demonstrate the capability of structures, systems, and components important to safety to withstand postulated accidents and environmental conditions. The detailed structural analysis of confinement structures is presented in the HI-STORM 100 FSAR. The staff has previously reviewed this structural analysis and found it acceptable, as documented in the staff's HI-STORM 100 SER. As documented in that SER, the structural analysis shows that the structural integrity of the HI-STORM 100 Cask System is maintained under all credible loads analyzed in the HI-STORM 100 FSAR.

The PFS Facility SAR provides a summary of the analysis performed in the HI-STORM 100 FSAR. The loading conditions at the Facility are enveloped by the loading conditions considered in the HI-STORM 100 FSAR (Holtec International, 2000), except for the seismic loads. To fully characterize the response of the system at the PFSF, Holtec International performed site-specific analyses of the HI-STORM 100 Cask system for thermal, seismic, and drop/tipover loads at the PFS site.

For the analysis of the storage cask, the dead load of the cask and the spent nuclear fuel canister were considered. The loads are bounded by those identified in the HI-STAR 100 FSAR. Under the applied dead loads the resulting stress levels are shown in the HI-STORM 100 FSAR to be within applicable code allowables. Since the PFS cask dead loads are bounded by the loads in the HI-STAR 100 FSAR, the stresses in the HI-STORM 100 FSAR for dead loads bound the PFS Facility design criteria in Section 3.2.1 of the SAR for dead loads.

Live loads considered for the storage cask include the snow and ice loads and the HI-TRAC transfer cask weight containing a fully loaded canister. The HI-STORM 100 FSAR uses a 100 psf snow load which bounds the 45 psf snow load applicable at the site. The live load capacity of the storage cask from the weight of the HI-TRAC transfer cask with a fully loaded canister is shown in Section 3.4.4.3.2.1 of the HI-STORM FSAR to be adequate. The live loads used in the HI-STORM analysis bound the PFS Facility design criteria specified in Sections 3.2.2 and 3.2.3 for live loads and snow loads.

Differential internal and external pressure loads are not applicable to the vented concrete storage cask. A discussion of the thermal design of the storage cask is given in Section 4.2.1.5.2 of the SAR. Thermal analyses were performed to evaluate the steady-state temperature for components of the storage system (Holtec International, 1999, 2001a). The analysis included consideration of the physical characteristics of the cask storage pad, adjacent casks, and worst case condition of heat generated within the spent nuclear fuel canisters. A summary of the steady state temperature is given in Table 4.2-3 of the SAR. The thermal design of the HI-STORM 100 storage system bounds the site-specific design requirements. The structural analysis demonstrates that the storage cask is designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events in accordance with the requirements of 10 CFR 72.122(b)(1).

The staff has reviewed Section 4.2 of the SAR and found that the design of storage casks to mitigate environmental effects is identified and that Chapter 8 and Sections 8.2.1.1, 8.2.1.2, and 8.2.2.2 of the SAR demonstrate the capability of structures, systems, and components important to safety to withstand postulated accidents and environmental conditions. Analysis of the structural response of the storage cask to the earthquake load was based on generic loading identified in the HI-STORM 100 FSAR and the PFS Facility site-specific seismic events. As identified in Section 4.2.3.5.4 of the SAR, the cask stability analysis ensures the storage casks will not tipover or slide excessively during a seismic event. The cask stability analysis for a generic design basis earthquake is given in Section 3.4.7 of the HI-STORM 100 FSAR. Additionally, a site-specific cask stability analysis was performed by Holtec International that demonstrates the storage cask will not tipover, collide, or slide off the storage pad during a site-specific design basis earthquake (Holtec International, 2001b, c). The cask stability analyses are described in detail in Section 8.2.1 of the SAR.

Analysis of the structural response of the storage cask to the earthquake load was based on loading identified in the HI-STORM 100 FSAR and the PFS Facility site-specific seismic events. As identified in Section 4.2.3.5.4 of the PFS SAR, the cask stability analysis ensures the storage casks will not tipover or slide excessively during a seismic event. The cask stability analysis for a generic design basis earthquake is given in Section 3.4.7 of the HI-STORM 100 FSAR. Additionally, a site-specific cask stability analysis was performed by Holtec International that demonstrates the storage cask will not tipover, collide with another cask, or slide off the storage pad during a site-specific design basis earthquake (Holtec International, 2001a). The

analysis was performed two ways. For the first case it was assumed that the concrete pad, the soil-cement layer, and the underlying soil were fully bonded. For the second case, the concrete pad and soil-cement layer were allowed to slide when frictional resistance exceeded the limits. Based on this analysis it was concluded that the casks will remain stable during a seismic event. The cask stability analyses are described in detail in Section 8.2.1 of the PFS SAR. The inertia loads and resulting stresses in the MPC produced by the seismic event are less than the 45 g loads associated with the non-mechanistic tipover and vertical drop events. Therefore, the staff's conclusions in its HI-STORM 100 SER with respect to the structural integrity of the storage cask are valid for the PFS Facility. The HI-STORM design meets the PFS Facility design criteria in Section 3.2.10 of the PFS Facility SAR for seismic design.

The analysis considers a single 30 ft x 67 ft x 3 ft. concrete pad supporting up to eight HI-STORM 100 storage casks. The concrete storage pad is modeled as a rigid plate structure supported on linear springs that characterize the behavior of the underlying foundation under dynamic loading from a seismic event. PFS uses bounding values for soil properties (Young's Modulus, Shear Modulus, and Poisson's Ratio) that conform to those identified in Chapter 2 of the SAR. Using the smaller values of Young's Modulus and Shear Modulus coupled with the larger value of Poisson's Ratio, results in a lower value for the soil spring constants. Conversely, using the larger values of Young's Modulus and Shear Modulus coupled with the smaller value of Poisson's Ratio, results in a higher value for the soil spring constants. The sensitivity analysis demonstrates that variations in soil moduli leading to upper and lower bound estimates of the soil springs at the Facility pad interface have minimal effect on the maximum cask excursion. The lower bound values give rise to large cask displacements, resulting in the bounding analysis for displacement.

The cask system weight and dimensions are the same as the HI-STORM 100 storage system. Each cask is modeled as a mass-spring system with appropriate nonlinear characteristics to simulate compression-only contact, impact, and lift-off of the cask from the slab. The layout of the casks on the slab allots a 15 ft × 16 ft pad space for each of the spent fuel casks. The minimum spacing between casks is 48 in. The model adequately represents the physical system.

The time histories used as the seismic input correspond to the 2000-yr event with 0.71 g in two horizontal directions and 0.695 g in the vertical direction (Stone & Webster Engineering Corporation, 2001b).

The acceptance criterion was that the casks must be stable in the sense that the center of the top cover of the cask must remain within the original contact circle that the cask makes with the pad. The maximum rocking at the top was less than 4 in. The maximum sliding was less than 3 in. This is significantly less than the spacing between the casks themselves and the edge of the pad. Consequently, the cask will not tipover, slide off the pad, or impact adjacent casks during a site-specific design basis earthquake. Holtec International performed additional analyses (Holtec International, 2001a) that allowed slip between the pad and soil. Under that

condition, the maximum cask excursions relative to the pad did not exceed 0.02 in at the top or bottom of the cask. Therefore, the structural analysis demonstrates that the storage cask is designed to withstand the effects of site-specific earthquakes without impairing the capability to perform safety functions, in accordance with the requirements of 10 CFR 72.122(b)(2).

The wind loading is enveloped by the tornado wind load conditions. Tornado wind and tornado missile loads are addressed in HI-STORM 100 FSAR Sections 3.1.2.1.1.5 and 3.4.8. Section 4.2.1.5.1 of the SAR specifies that the postulated missile loads used in the HI-STORM 100 analysis are the same as in the Facility design criteria. The SAR tornado missiles are identified as Spectrum II missiles (Section 3.5.1.4 of NUREG–0800). All six of the Spectrum II missiles identified in NUREG–0800 are used as the Facility design criteria. The HI-STORM 100 FSAR identifies the three design basis tornado missiles as Spectrum I missiles (Section 3.5.1.4 of NUREG–0800). Both the SAR and the HI-STORM 100 FSAR are in compliance with the requirement of NUREG–0800. Since the HI-STORM 100 cask design criteria for tornado wind and tornado-generated missile bound the Facility design criteria, the HI-STORM 100 design meets the Facility design criteria. Holtec International performed an additional analysis to determine the influence of reducing the compressive strength of the cask concrete from 4,200 psi to 3,000 psi (Holtec International, 2001d). The analysis showed that there was additional penetration into the concrete but the confinement barrier was not breached. The structural analysis demonstrates that the storage cask is designed to withstand the effects of natural phenomena such as tornadoes without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

The storage casks will not be subject to flood loads. The location of the storage pads is above the maximum probable flood level. In addition, the area is protected by an earthen berm to prevent sheet flow over the pads.

Lightning is addressed in HI-STORM 100 FSAR Sections 2.2.3.11 and 11.2.12. The HI-STORM 100 system is a large steel/concrete cask that will discharge lightning current through the steel shell of the overpack, to the ground. The conductive carbon steel overpack outer shell will provide a direct path to ground. Since the lightning current will discharge through the overpack, the MPC will be unaffected. Therefore, the HI-STORM 100 storage cask design meets the PFS Facility design criteria in Section 3.2.12 of the PFS Facility SAR for lightning protection

The staff has reviewed Sections 4.2.1.5.1(l) and (j), 4.2.2.5.1(l) and (j), 4.7.3.5.1(e), and 4.7.4.5.1(d) of the SAR and determined that the design of the cask storage pads provides fire and explosion protection while Sections 8.2.4.2 and 8.2.5.2 of the SAR show the capability of structures, systems, and components important to safety to withstand postulated fire and explosion accidents. The PFS Facility concrete storage pads are located on an open gravel surface and, therefore, will not be subject to wildfires. Therefore, consideration of fire loading on the storage casks is not necessary. The short duration of the 50-gal. diesel fuel fire does not produce a significant increase in the temperature of the massive concrete structure. A

complete analysis of potential fires is presented in Chapter 15 of this SER. The explosive pressure loads for the PFS Facility site are identified as less than 1 psi. This is significantly less than the external pressure load of 60 psi used in the vendor Topical (T)SAR. The design of the storage cask has been shown to be acceptable under these greater load conditions.

Based on a review of the PFS site specific loads as discussed above, the staff concludes that the PFS Facility design criteria meet the loading conditions identified the HI-STORM storage cask design. A discussion of the cask design relative to the storage requirements of the PFS Facility is provided in SAR Chapter 4, Facility Design. The PFS Facility SAR provides a summary of the analysis performed in the HI-STORM 100 FSAR. The loading conditions at the Facility are enveloped by the loading conditions considered in the HI-STORM 100 FSAR (Holtec International, 2001), except for the seismic loads. Holtec International performed site-specific analysis of the HI-STORM 100 Cask system for thermal evaluation, multi-cask response under seismic loading, and drop/tipover analysis, and concluded that the PFS designs meet the requirements of 10 CFR 72.122.

The staff has reviewed these analyses and finds them acceptable

Transfer Cask and Associated Lifting Devices

The staff reviewed Sections 4.7.3, 8.2.1, 8.2.4, and 8.2.5 of the SAR which contain the structural analysis of the HI-TRAC transfer cask and associated lifting devices. The detailed structural analysis of the HI-TRAC transfer cask and the staff's evaluation are respectively provided in the HI-STORM 100 FSAR and the NRC's related SER. The discussion below is based in part on the results presented in the HI-STORM 100 FSAR and summarized in the PFS Facility SAR.

The transfer cask lifting trunnions are designed for a conservative total lifting load of 376,000 lb (150 percent of loaded transfer cask) using a two-point lift with a minimum safety factor of 10 based on the ultimate strength. During a lifting operation, no point in the HI-TRAC body exceeds its material yield strength. The structural analysis for the HI-TRAC transfer cask trunnions is described in the HI-STORM FSAR Appendix 3.E.

The HI-TRAC transfer cask, with the transfer lid attached, is designed to meet ASME Level A Subsection NF (American Society of Mechanical Engineers, 1998) stress limits while handling the dead load of the heaviest loaded canister. The structural analysis for the HI-TRAC transfer cask is described in HI-STORM 100 FSAR Appendix 3.AD.

Structural adequacy of the transfer cask trunnions was evaluated by modeling the trunnions as cantilevers and applying the weight of the loaded transfer cask. The resulting bending and shear stresses in the trunnions were combined to calculate the maximum principal stress and determine the corresponding safety factors. The structural analysis for the transfer cask trunnions is contained in the HI-STORM 100 FSAR.

The shipping cask and transfer cask lift yokes are designed as non-redundant lifting devices with a factor of safety of 10 or greater on material ultimate strength and 6 or greater on yield strength. A dynamic load increase factor of 10 percent has been applied to the lifting loads. Therefore, the lift yokes meet the NUREG–0612 stress limits for non-redundant special lifting devices.

The canister downloader is designed in accordance with NUREG–0612. The downloader consists of a hydraulic ram that is a non-redundant lifting device designed with the safety factors of 10 on ultimate strength and 6 on yield strength. The downloader uses two redundant sets of anti-drop cam locks to secure the load in the event of a loss of power or hydraulic pressure.

The two canister lift cleats are designed with a minimum factor of safety of 3 on material yield strength and 5 on material ultimate strength, as well as a dynamic load increase factor of 10 percent. Each cleat can totally support the weight of the canister, thereby making them single-failure-proof per NUREG-0612. The cleats are connected to the canister via the 4 lifting bolts, 2 bolts per cleat. The lifting bolts are installed into threaded holes on top of the MPC lid. The MPC lifting analysis, which includes an analysis of the lifting bolts, is described in the HI-STORM FSAR.

The HI-STORM storage cask is designed to be lifted using four lifting lugs (threaded eyebolts) located on top of the cask. The lifting lugs screw into steel lifting blocks that are integrally welded to the storage cask steel. The stresses were compared with ASME III, Subsection NF allowable (American Society of Mechanical Engineers, 1998). The thread shear in the lifting block is compared to 10 percent of the ultimate strength of the base material in accordance with NUREG–0612. The lifting lugs have a net section stress below 10 percent of the ultimate strength of the lug material. The strength qualification analysis is described in HI-STORM FSAR Appendix 3.D. No credit is assumed for the concrete except as a vehicle to transfer compressive loads. A dynamic load factor of 1.15 is applied to simulate anticipated inertia forces during a low speed lift.

The canister hoist rings are designed with a minimum factor of safety of three on material yield strength and five on material ultimate strength, as well as a dynamic load increase factor of 10 percent. Eight rings provide redundant capability since only four are required, therefore, the hoist rings meet the NUREG–0612 requirements for redundancy.

The structural analysis demonstrates that the transfer cask and associated lifting devices are designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during off-normal and accident events. The structural analysis demonstrates that the transfer cask and associated lifting devices are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods without impairing the capability to perform safety functions.

The transfer cask has been evaluated for stability during a seismic event when in the stacked cask arrangement. It was concluded that it is necessary to secure the transfer, storage, and shipping casks to the cell walls throughout the transfer operation to prevent the casks from toppling during a seismic event. Therefore, seismic support struts are used to secure the casks to the cell walls when the casks are in a stacked arrangement.

Fire loading conditions of the HI-TRAC transfer cask are addressed in Section 11.2.4 of the HI-STORM 100 FSAR and in Section 8.2.5 of the PFS Facility SAR. As shown in Section 8.2.5 of the PFS Facility SAR, fires near a loaded transfer cask would have a small effect on the canister temperature because of the short duration of the fire accidents. A bounding cask temperature rise of less than 9.3 °F per minute was determined from the combined radiant and convection heat input to the cask. As a result, the fuel cladding was shown not to exceed the accident condition fuel cladding temperature limits. The elevated temperatures from a fire could cause the pressure in the transfer cask water jacket to increase and cause the overpressure relief valve to open and release water from the water jacket. Loss of water in the HI-TRAC water jacket is analyzed in the HI-STORM 100 FSAR. The FSAR indicates that fuel cladding, MPC, and transfer cask temperatures would remain below the design temperature limits. The dose rates would not exceed the 10 CFR 72.106(b) whole body and organ-specific dose limits. The FSAR also indicates that the estimated occupational exposure for recovery of a damaged HI-TRAC transfer cask would be less than 2000 person-mrem and the 10 CFR Part 20 limits would be met.

Canister Transfer Overhead Bridge and Semi-Gantry Cranes

The cranes will be designed, fabricated, and tested in accordance with ASME NOG–1. The staff has reviewed Sections 4.7.2, 8.1.1, 8.1.4, 8.2.1, 8.2.4, 8.2.5, and 8.2.6 of the SAR and found that the design of the cranes to mitigate environmental effects is identified and that the capability of the cranes to withstand postulated accidents is demonstrated. The structural analyses of the canister transfer overhead bridge and semi-gantry cranes were performed by the applicant using a three-dimensional finite element model of the systems (Anatech Corporation, 1998a,b). In each case, the major structural members were sized based on the preliminary design and then adjusted to provide acceptable stress conditions in the members. The major structural elements were idealized as beam members with appropriate offsets to account for the physical relationships between the centroids of the various beam members. The restraints applied to the structural analysis model were in accordance with the procedures given in ASME NOG–1 (American Society of Mechanical Engineers, 1989) and NUREG–0554. The loading included dead loads, maximum suspended weight, and seismic loads. Load cases were run for each of the following conditions:

- Trolley at one end
- Trolley at ¼ span
- Trolley at ½ span

- Load at maximum height
- Load at minimum height

ASME NOG–1 is accepted by the NRC as a design specification for cranes. The Technical Specifications require that the overhead bridge crane and semi-gantry crane be classified as Type I cranes in accordance with ASME NOG-1, and that the allowable stresses used in the crane designs shall be in accordance with ASME NOG-1. Further, the Technical Specifications require that the cranes, and the canister downloader, be of single-failure-proof design and meet the requirements of NUREG-0554 and NUREG-0612.

Based on the crane design specifications and the Technical Specification requirements, there is reasonable assurance that overhead bridge and semi-gantry cranes will resist site-specific loads during normal operations and during off-normal and accident events, in accordance with the requirements of 10 CFR 72.122(b)(1). There is also reasonable assurance that the canister transfer overhead bridge and semi-gantry cranes will withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

Seismic Support Struts

The staff has reviewed Sections 4.7.1.4.1 of the SAR and SC-10 (Stone & Webster Engineering Corporation, 1999b) and found that the design of the seismic struts to mitigate environmental effects is identified and that the capability to withstand postulated accidents is demonstrated. The seismic support struts secure the transfer, storage, and shipping casks to the cell walls when the casks are in a stacked arrangement during transfer operations. The seismic support struts prevent the casks from toppling or tipping over during a seismic event. The size of the struts and the design of the attachment to the building were based on the loads from an equivalent static seismic analysis (Stone & Webster Engineering Corporation, 1999b). ASME Subsection NF requirements for Class 2 nuclear grade support are accepted by the staff as a design specification of the support structures. The basic structure of the clevis used for connection of the seismic struts to the cask is based on standard end connections of Berge-Patterson Pipe Corporation. Also, as required in the Technical Specifications, the structural connection between the seismic support struts and the transfer cask, storage cask, and shipping cask will be sufficiently rigid to resist the design basis seismic motions. The structural analysis demonstrates that the seismic support struts are designed to resist the loads based on the site characteristics and environmental conditions during normal operations and during postulated off-normal and accident events, in accordance with the requirements of 10 CFR 72.122(b)(1). The structural analysis demonstrates that the seismic support struts are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods, without impairing the capability to perform safety functions in accordance with the requirements of 10 CFR 72.122(b)(2).

Canister Transfer Building Structural Steel Roof Beams

The staff has reviewed SC-12 (Stone & Webster Engineering Corporation, 2001i) and found that the design of the Canister Transfer Building structural steel roof beams to mitigate environmental effects is identified and that the capability to withstand postulated accidents is demonstrated. Vertical loads are transferred to the building walls and structural steel columns that are supported by the mat foundation of the Canister Transfer Building. Horizontal seismic load from the roof mass is transferred to the building's walls by diaphragm action of the roof slab. Specific design and analysis is performed for the 25 ft and 30 ft span upper roof steel, girders G1, G2, and G3, the 17 ft to 30 ft span lower roof steel, roof support beams, columns, embeds, and connections.

Loads on the upper roof steel are based on a conservative spacing of 5.25 ft, which is greater than the actual spacing in all cases. Since the upper roof steel is welded to the decking it is considered to be continuously supported for positive moment. Therefore the allowable moment for the section can be fully realized. For negative moments the beam is unsupported and the section properties and procedures given in ANSI/AISC N690 are used. The appropriate sections were selected to insure that they have sufficient capacity to meet the demands under all loading conditions.

Tapered girders, 5 ft 3.75 inches at the centerline and 4 ft at the ends, are used to support the upper roof steel. The 63 ft long girders have a stiffened ½ inch thick web. The width and thickness of the flanges are adjusted for the three locations , G1 to G3, to account for variations in demand loads. The design of the girders considers the appropriate load combinations and design considerations given in ANSI/AISC N690.

Design of the lower roof steel follows the same procedures as the upper roof steel. The appropriate sections were selected to assure that they have sufficient capacity to meet the demands under all loading conditions. The design of the lower roof steel considers the appropriate load combinations and design considerations given in ANSI/AISC N690.

The roof steel is supported by support beams. In addition to having sufficient moment and shear capacity, the deflection of these beams is shown to be within acceptable limits in accordance with the requirements of ANSI/AISC N690.

In addition to the reinforced concrete walls, the Canister Transfer Building structural steel roof members are supported in some locations by structural steel columns. These columns are designed considering axial and bending moments, along with combined loading conditions in accordance with the requirements of ANSI/AISC N690.

The roof beams are also supported by embeds into the reinforced concrete walls. These embeds consist of a series of 3/4 inch diameter studs welded to a plate. PFS stated that the capacity of the plate in shear will be calculated using a finite element analysis during the

detailed design when the calculations for the wall have been finalized in SC-7. (Stone & Webster Engineering Corporation, 1998b) Stone & Webster in SC-12 calculation also identifies the details associated with the connection between various elements of the structural steel. Both the embeds and connectors are designed in accordance with the requirements of ANSI/AISC N690.

As identified in SC-12, the input accelerations, wind loads, and snowdrift will be verified by the applicant using the results of the updated finite element analysis of the Canister Transfer Building (SC-6) and the design of the reinforcing steel for the Canister Transfer Building (SC-7).

Based on a review of the analysis presented in SC-12, the staff concludes that the methods used by the applicant to analyze the Canister Transfer Building Structural Steel Roof for normal operations, off-normal, and accident events loads are reasonable, and meet the requirements of 10 CFR 72.24 and 72.122.

Canister Transfer Building Transfer Cell Doors

Stone and Webster in SC-14 determined that the design of the east and west sliding doors of the three canister transfer cells is adequate to ensure these doors are capable of resisting the required loadings. The loadings include the design basis ground motions for all doors and the tornado-missile loading for the west doors.

The doors are analyzed for earthquake loads using a static equivalent method and the peak earthquake acceleration. Computed stresses were compared with the requirements of the design code ANSI/AISC N690. Two bounding cases, one with the rolling doors in fully open, the other in fully closed positions were considered in the evaluation for the earthquake loads. For tornado missile protection, a finite element analysis was performed to determine the force required to obtain a plastic moment in the door, and to develop the force-displacement relationship.

Based on a review of the analysis presented in SC-14, the staff concludes that the methods used by the applicant to analyze the Canister Transfer Building Transfer Cell Doors for normal operations, off-normal, and accident event loads are reasonable, and meet the requirements of 10 CFR 72.24 and 72.122.

REMOVE section 5.3 of the SER and INSERT:

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