5 INSTALLATION AND STRUCTURAL EVALUATION

5.1 Conduct of Review

This chapter of the Safety Evaluation Report (SER) reviews information presented in Chapter 4, "Installation Design," of the Safety Analysis Report (SAR) (Foster Wheeler Environmental Corporation, 2003a). The review also considers selected sections of and documents referenced in Chapters 1, 2, 3, and 8 of the SAR. These chapters in the SAR discuss general information, site characteristics, principal design criteria, and accident analysis. The installation and structural design review ensures appropriate consideration of (i) site characteristics; (ii) structural integrity of structures, systems, and components with emphasis on those important to safety; and (iii) input from and support to other evaluation areas.

Spent nuclear fuel (SNF) dry storage facilities are designed for safe confinement and storage of the SNF. The design of the proposed Idaho Spent Fuel (ISF) facility is based on the use of the ISF canister and ISF storage tube for confinement and radiological safety. During handling of the SNF, the fuel packaging area (FPA) confinement boundary structure provides for confinement and radiological safety.

The major categories of safety protection systems discussed in this chapter of the SER include confinement structures, systems, and components; reinforced concrete structures; structures, systems, and components important to safety; and structures, systems, and components not important to safety.

This chapter also reviews the information presented in Chapter 4 of Appendix A of the SAR, which discusses the structural evaluation of the transfer cask provided by the U.S. Department of Energy. The review also considers selected sections and documents referenced in Chapters 1, 3, and 8 of Appendix A of the SAR. These chapters discuss general information, principal design criteria, and the accident analyses for the transfer cask.

The staff reviewed the ISF Facility installation and structural evaluation and the transfer cask structural evaluation with respect to the following regulatory requirements.

- 10 CFR §72.24(a) requires a description and safety assessment of the site on which the ISF facility is to be located, with appropriate attention to the design bases for external events. Such assessment must contain an analysis and evaluation of the major structures, systems, and components of the ISF Facility that bear on the suitability of the site when the ISF facility is operated at its design capacity.

- 10 CFR §72.24(b) requires a description and discussion of the ISF Facility structures with special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations.

- 10 CFR §72.24(c) requires that the design of the ISF facility be described in sufficient detail to support the findings in §72.40, including (1) The design criteria for the ISF Facility pursuant to subpart F of this part, with identification and justification for any additions to or departures from the general design criteria; (2) the design bases and the relation of the design bases to the design criteria; (3) information relative to materials of

construction, general arrangement, dimensions of principal structures, and descriptions of all structures, systems, and components important to safety, in sufficient detail to support a finding that the ISF Facility will satisfy the design bases with an adequate margin for safety; and (4) applicable codes and standards.

- 10 CFR §72.24(d)(1) requires that an analysis and evaluation be provided of the design and performance of structures, systems, and components important to safety, with the objective of assessing the impact on public health and safety resulting from operation of the ISF Facility and including determination of the margins of safety during normal operations and expected operational occurrences during the life of the ISF Facility.

- 10 CFR §72.24(d)(2) requires that an analysis and evaluation be provided of the design and performance of structures, systems, and components important to safety, with the objective of assessing the impact on public health and safety resulting from operation of the ISF Facility and including determination of the adequacy of structures, systems, and components provided for the prevention of accidents and the mitigation of the consequences of accidents, including natural and manmade phenomena and events.

- 10 CFR §72.120(a) requires that, pursuant to the provisions of Section 72.24, an application to store spent fuel in an ISF Facility include the design criteria for the proposed storage installation. These design criteria establish the design, fabrication, construction, testing, maintenance, and performance requirements for structures, systems, and components important to safety as defined in Section 72.3. The general design criteria identified in this subpart establish minimum requirements for the design criteria for an ISF Facility. Any omissions in these general design criteria do not relieve the applicant from the requirement of providing the necessary safety features in the design of the ISF Facility.

- 10 CFR §72.122(a) requires that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety of the function to be performed.

- 10 CFR §72.122(b)(1) requires that structures, systems, and components important to safety be designed to accommodate the effects of, and to be compatible with, site characteristics and environmental conditions associated with normal operation, maintenance, and testing of the ISF Facility and to withstand postulated accidents.

- 10 CFR §72.122(b)(2) requires that structures, systems, and components important to safety be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, hurricanes, floods, tsunami, and seiches, without impairing their capability to perform safety functions. The design bases for these structures, systems, and components must reflect (1) appropriate consideration of the most severe of the natural phenomena reported for the site and surrounding area, with appropriate margins to take into account the limitations of the data and the period of time in which the data have accumulated, and (2) appropriate combinations of the effects of normal and accident conditions and the effects of natural phenomena. The ISF Facility should also be designed to prevent massive collapse of building structures or the dropping of heavy objects as a result of building structural failure on the spent fuel or onto structures, systems, and components important to safety.

- 10 CFR §72.122(c) requires that structures, systems, and components important to safety be designed and located so that they can continue to perform their safety functions effectively under credible fire and explosion exposure conditions. Noncombustible and heat-resistant materials must be used wherever practical throughout the ISF Facility, particularly in locations vital to the control of radioactive materials and to the maintenance of safety control functions. The design of the ISF Facility must include provisions to protect against adverse effects that might result from either the operation or the failure of the fire suppression system.

- 10 CFR §72.122(f) requires that systems and components that are important to safety be designed to permit inspection, maintenance, and testing.

- 10 CFR §72.122(g) requires that structures, systems, and components important to safety be designed for emergencies. The design must provide for accessibility to the equipment of onsite and available offsite emergency facilities and services such as hospitals, fire and police departments, ambulance service, and other emergency agencies.

- 10 CFR §72.122(h)(1) requires that the spent fuel cladding must be protected during storage against degradation that leads to gross ruptures or the fuel must be otherwise confined such that degradation of the fuel during storage will not pose operational safety problems with respect to its removal from storage. This may be accomplished by canning of consolidated fuel rods or unconsolidated assemblies or other means as appropriate.

- 10 CFR §72.122(l) requires that storage systems must be designed to allow ready retrieval of spent fuel for further processing or disposal.

- 10 CFR §72.126(a) requires that radiation protection systems must be provided for all areas and operations where onsite personnel may be exposed to radiation or airborne radioactive materials. Structures, systems, and components for which operation, maintenance, and required inspections may involve occupational exposure must be designed, fabricated, located, shielded, controlled, and tested so as to control external and internal radiation exposures to personnel. The design must include means to (1) prevent the accumulation of radioactive material in those systems requiring access; (2) decontaminate those systems to which access is required; (3) control access to areas of potential contamination or high radiation within the ISF Facility; (4) measure and control contamination of areas requiring access; (5) minimize the time required to perform work in the vicinity of radioactive components, for example, by providing sufficient space for ease of operation and designing equipment for ease of repair and replacement; and (6) shield personnel from radiation exposure.

- 10 CFR §72.128(a) requires that spent fuel storage and other systems that might contain or handle radioactive materials associated with spent fuel be designed to ensure adequate safety under normal and accident conditions. These systems must be designed with (1) a capability to test and monitor components important to safety, (2) suitable shielding for radioactive protection under normal and accident conditions, (3) confinement structures and systems, (4) a heat-removal capability having testability

and reliability consistent with its importance to safety, and (5) means to minimize the quantity of radioactive wastes generated.

5.1.1 Confinement Structures, Systems, and Components

5.1.1.1 Description of Confinement Structures

The discussion on confinement structures, systems, and components is presented in Sections 4.2, "Storage Structures;" 4.3, "Auxiliary Systems;" and 4.7, "Spent Fuel Handling Operational Systems," of the SAR. The SNF is brought to the ISF Facility in the sealed transfer casks provided by the U.S. Department of Energy–Idaho Operations Office. The transfer cask acts as the confinement structure during this phase of the process. While the SNF is being transferred to the ISF canisters, the confinement structure consists of the FPA confinement boundary including parts of the heating, ventilation, and air conditioning (HVAC) system ducts and filters. Storage of SNF at the ISF Facility is based on the use of an ISF canister placed within an ISF storage tube. The ISF canister and ISF storage tube are sealed confinement boundaries. The storage tubes are located in the ISF storage area reinforced concrete vaults. The staff reviewed the discussion on confinement structures, systems, and components with respect to the applicable regulatory requirements.

U.S. Department of Energy Transfer Casks and Fuel Containers

The staff reviewed Section 4.7.1.1, "Peach Bottom Casks," of Appendix A of the SAR. This section provides a summary description of the transfer casks including materials of construction, fabrication details, engineering drawings, and testing. The transfer cask is the primary confinement structure for the SNF, while being handled within the cask receipt area (CRA) of the ISF Facility. The transfer cask is a heavy-walled cylindrical vessel constructed of carbon steel, stainless steel, and lead filled for radiation shielding (Figures A–5 and A–6 of Appendix A of the SAR) as required by 10 CFR §72.126(a). The transfer cask provides an internal cylindrical cavity for housing the three types of fuels identified for transfer to the ISF Facility. The SNF is housed in baskets and/or canisters within this internal cylindrical cavity to maintain a subcritical condition. An alternative lid for the transfer cask has been designed for operation with the Peach Bottom Core 1 fuel baskets (Figure A–7 of Appendix A of the SAR). Trunnions are welded to the cask to provide attachment support to upright and lift the cask from the transfer trailer. The only difference between the transfer casks designated Peach Bottom–1 and Peach Bottom–2 is the trunnion positions are slightly different. This difference affects only the interface with the transport trailers.

The transfer cask has been sufficiently described in accordance with the requirements of 10 CFR §72.24(a) and §72.24(b). Descriptions of the transfer cask and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f).

FPA Confinement Barrier

The FPA and fuel handling machine (FHM) maintenance area provide a confinement barrier during SNF transfer operations and are designed to maintain this function during normal,

off-normal, and accident conditions. During SNF packaging operations, the confinement boundary as shown in Figure 4.3-5 of the SAR is provided by physical barriers formed by:

- Concrete floor, ceiling, and walls;
- Shield windows;
- Sealed wall penetrations;
- High-efficiency particulate air (HEPA) filters and portions of HVAC ductwork;
- Personnel shielded access door into the FHM maintenance area;
- FHM maintenance area hoist well;
- Port plugs located in the floor of the FPA; and
- Inflatable seals at the canister and cask ports.

The FPA, shown in Figures 4.3-15 and 4.7-13 of the SAR, is a shielded, tornado protected, seismically designed confinement barrier. The FPA is constructed of thick reinforced concrete walls, floor, and ceiling. Four shield windows on the south wall and three shield windows on the north wall provide visual observation stations for operators during SNF handling operations. The shield window assembly has a sealed-glass plate fixed to the window liner inside the FPA that prevents the spread of radioactive contamination if the shield window is removed from the window liner for maintenance. Through-wall penetrations in the walls of the FPA are designed to minimize radiation dose rates to operators in the operating gallery.

Portions of the ventilation ductwork and HEPA filters that form part of the confinement barrier for the FPA and FHM maintenance area are classified as important to safety. HEPA filters are also installed inside the FPA on the inlet to the exhaust ductwork to remove radioactive particulate from the air leaving this area. These filters also serve as a passive confinement barrier during off-normal and accident conditions. Fire and tornado dampers are provided at ductwork penetrations into the FPA and the FHM maintenance area.

On the west end of the FPA is an area designated for maintenance of the FHM. A personnel shielded access door (Figure 4.7-20 of the SAR) is built into the wall of the FHM maintenance area to allow personnel access to perform maintenance on the FHM. This hinged steel door is sized for radiation protection and to withstand seismic and tornado accident conditions. This door is 7.62 cm [3 in] thick. The FHM maintenance area hoist well allows equipment to be moved into the area and is designed for radiation protection and confinement and to withstand seismic and tornado accident conditions.

Several ports are in the floor of the FPA (Figure 4.7-13 of the SAR). During normal operations, these ports are sealed with plugs constructed of steel and concrete. The design of the port plugs provides radiation protection and a confinement boundary. During transfer operations, these ports are sealed by inflatable seals (Figures 4.7-11 and 4.7-12 of the SAR). The inflatable seals are designed to fail safe. In event of power loss, these seals are in the inflated condition to maintain the confinement boundary.

The SAR provides a design description of the ISF Facility FPA confinement barrier in sufficient detail to support a detailed review and evaluation in accordance with 10 CFR §72.24(a) and §72.24(b). Descriptions of the ISF Facility FPA confinement barrier and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). This FPA confinement barrier also incorporates the capability for retrieving the SNF as required by 10 CFR §72.122(l).

ISF Canister

As discussed in the SAR, the ISF canister consists of the canister body assembly and the canister lid assembly (Figures 4.2-7 and 4.2-8 of the SAR). These two assemblies are welded together in the canister closure area (CCA) after being loaded with SNF to complete the canister assembly. The ISF canister is classified as important to safety. The ISF Facility uses three canister configurations:

- 45.7-cm [18-in] outside diameter, 4.57 m [15 ft] long;
- 45.7-cm [18-in] outside diameter, 3.05 m [10 ft] long ; and
- 61.0-cm [24-in] outside diameter, 4.57 m [15 ft] long.

The canister body consists of a formed head welded to a pipe section that creates the body cavity. The ISF canister (confinement barrier) is an N-stamped ASME Code, Section III, Division 1, Subsection NB (Class 1) vessel (ASME International, 1998a). The general arrangement of an ISF canister is shown in Figure 4.2-15 of the SAR. A short length of pipe is welded to the lower formed head to produce a base on which the canister can stand and which provides for energy absorption during postulated drops. The canister lid consists of a formed head welded to a short length of pipe that provides the upper lifting feature for the canister, a vent plug, and a flange for interfacing with the vacuum connection tool. Integral impact plates are secured to the inside of the upper and lower formed heads. The impact plates support the internal baskets and transfer loads from the baskets to the canister shell. The canister shield plug is placed in the ISF canister between the upper impact plate and the top of the ISF basket, as shown in Figure 4.2-16 of the SAR. The shield plug is used to reduce the dose from the fuel in the canister during canister closing operations.

Fuel-specific ISF canister baskets are used with the ISF canister to provide a storage and transfer system vessel for the SNF at the ISF Facility. The ISF canister baskets include tubes, spacer discs and plates, tie bars, lids, and locking plates assembled into structures that provide location and support for the SNF elements within the ISF canister. The various arrangements of ISF canister and basket assemblies are shown in Figures 4.2-7 and 4.2-8 of the SAR. The ISF canister baskets that provide criticality control features are classified as important to safety. The Peach Bottom; Training, Research, and Isotope reactors built by General Atomics (TRIGA); and Shippingport canister baskets also are used for lifting and handling the fuel element within the FPA when they are transferred from bench vessels into the ISF canister.

There are three variations of ISF baskets for the Peach Bottom fuel: (i) Peach Bottom Core 1 fuel ISF basket (Figure 4.2-18 of the SAR), (ii) Peach Bottom Core 2 fuel ISF basket (Figure 4.2-18 of the SAR), and (iii) Peach Bottom Core 1 fuel attached removal tool ISF basket (Figure 4.2-19 of the SAR). Two types of TRIGA SNF are to be stored at the ISF Facility using one basket design (Figure 4.2-20 of the SAR). Because of the short length of TRIGA SNF, two TRIGA ISF baskets are stacked into a canister, one on top of the other. The lower ISF basket rests on the canister lower impact plate, and the upper ISF basket rests on the lid of the lower ISF basket. Spacers on the two ISF baskets minimize the axial free space within the canister. Three ISF basket configurations are required to store the Shippingport SNF: (i) Shippingport reflector IV module ISF basket (Figure 4.2-21 of the SAR), (ii) Shippingport reflector V module ISF basket (Figure 4.2-22 of the SAR), and (iii) Shippingport reflector rods ISF basket (Figure 4.2-23 of the SAR).

The ISF canister has been sufficiently described in accordance with the requirements of 10 CFR §72.24(a) and §72.24(b). Descriptions of the ISF canister and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). Radiation protection is designed into the ISF canister as required by 10 CFR §72.126(c). The ISF canister also incorporates the capability for retrieving the SNF. Consequently, the SNF can be retrieved in accordance with 10 CFR §72.122(l).

ISF Storage Tube

As discussed in the SAR (Foster Wheeler Environmental Corporation, 2003a), the ISF storage tube assembly consists of the storage tube body, storage tube lid and seals, and the internal storage tube plug (Figure 4.2-6 of the SAR). The pressure boundary components of the storage tube assembly are classified as important to safety because they provide the secondary confinement boundary for the SNF. The storage tubes are installed within the storage vaults. A support stool bolted to the vault floor locates the base of each storage tube, and the upper ends of the storage tubes are located by the penetrations through the charge face structure. The steel support stool (Figure 4.2-13 of the SAR), secured to the vault floor, provides both lateral and vertical location and support. The height of the stool is set during construction to provide sufficient axial clearance at the top end of the storage tube so that seismic and differential thermal movements do not introduce axial loads in the storage tube assembly.

ISF canisters are loaded into the ISF storage tubes using the canister handling machine (CHM). After the ISF canisters are loaded, an inert helium atmosphere is established within the ISF storage tube to prevent degradation of the canister during storage. Metal seal rings are used to create redundant seals between the ISF storage tube body and lid. Test ports on the ISF storage tube lid are provided to facilitate testing of the seals during the initial inert fill process and storage. The ISF storage tube is protected from tornado missile strikes by the charge face structure and the charge face cover plate. The charge face cover plate is bolted to the charge face encast to resist tornado wind pressure uplift. The support stool and the charge face cover plate are classified as important to safety.

The storage system provides two sizes of storage tube assembly—the 45.7- and 61.0-cm- [18-and 24-in]-diameter storage tubes. The storage tube assembly consists of the following main components: storage tube body; storage tube lid (incorporating evacuating and inert fill port), bolts, and metal seal rings; and storage tube plug.

The storage tube is a carbon steel tube welded to a forged flat closure plate at its bottom end. An annular forging is welded to the top end, to which a flat closure lid is bolted. Metallic double seal rings between the flat closure lid and the top forging complete the pressure boundary. Figure 4.2-11 of the SAR shows the detail of the storage tube seal rings and the interspace leak check port used to verify the storage tube lid is properly sealed.

The storage tube top forging (Figure 4.2-11 of the SAR) has an internally stepped shoulder that supports an internal shield plug used to maintain the overall charge face shielding. The external stepped diameters of the top forging also provide a shielding interface with the charge face encast. The top end of the storage tube is laterally centered by four equally spaced pads that form an annular gap between the outside diameter of the storage tube and the bore of the encast tube. This annular gap allows natural convection cooling flow to pass around the outside of the tube and up to the storage area building, as shown in Figure 4.2-10 of the SAR.

The storage tube plug (Figure 4.2-11 of the SAR) is positioned in the storage tube at charge face height and provides vertical shielding directly above the stored ISF canister. The tube plug is constructed of steel and concrete and is designed to withstand the temperature variations, external pressures, and vacuum experienced while the storage tube internals are subjected to operating pressure, evacuation, or leak testing.

The ISF storage tube has been sufficiently described in accordance with the requirements of 10 CFR §72.24(a) and §72.24(b). Descriptions of the ISF storage tube and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). The ISF storage tube also incorporates the capability for retrieving the SNF to satisfy the requirements of 10 CFR §72.122(l).

5.1.1.2 Design Criteria for Confinement Structures

Design criteria for the confinement structures have been shown in Chapter 4 of this SER to be representative of the site.

U.S. Department of Energy Transfer Casks and Fuel Containers

The staff reviewed Section 3.3.2.1.1, "Existing DOE–ID Transfer Cask," of Appendix A of the SAR. This section discusses the design criteria specific to the transfer casks. The transfer cask, with the transfer lid attached, is designed to meet a stress limit of one-third of the material yield strength while handling the dead load of the heaviest loaded canister. As stated, the transfer casks were not constructed to the requirements of Section III. Exceptions to the welding procedure of Section VIII (ASME International, 1962b) are included in the SAR and in the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b). Should an off-normal event occur, including any drop of a transfer cask, the applicant will evaluate the event. If necessary, the transfer cask will be returned to the possession of DOE-ID for inspection and performance of any necessary corrective action.

Appendix A, Section 3.2, of the SAR, "Structural and Mechanical Safety Criteria," addresses the structural and mechanical design criteria for the transfer casks. In general, design specifications for the transfer cask-related structures, systems and components important to safety are described in the analysis sections of the Appendix.

The design criteria for the transfer casks (listed in Table 5-1 of this SER) conform to standard engineering practice.

Additional details of the DOE-ID Peach Bottom transportation casks are included by reference to the Battelle Memorial Institute Safety Analysis Report (Battelle Memorial Institute, 1970) and to the Westinghouse Safety Analysis for shipment of LWBR fuel in the Peach Bottom-2 transfer cask from Expended Care Facility to Idaho Chemical Processing Plant (Westinghouse Electric Corporation, 1986).

Drop analyses for the transfer casks have been performed by DOE-ID and are referenced in Section 12 of Appendix A of the SAR. These analyses indicate that the transfer cask will maintain confinement when subjected to nonmechanistic drop scenarios, which bound all

potential drop heights encountered in the ISF Facility. Additional drop analyses performed by DOE-ID have also been provided.

Findings for the trunnion structural design are based upon the evaluation of Section 4.7.3.3.1 of Appendix A of the SAR and from the applicant's responses to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003c). The transfer cask trunnions have been evaluated as single-failure-proof interface lift points, per Section 5.1.6(3) of NUREG–0612, for which the design factor need only be evaluated with respect to the ultimate strength of the trunnion material.

Table 5-1. Summary of transfer cask structural design criteria

Design Parameters	Design Conditions	Applicable Criteria and Codes
Transfer cask	Containment and transport of fuel canisters	NUREG–1536,
Transfer cask trunnions	Single-failure-proof 29,484 kg (65,000 pound) lift load	NUREG–0612

The original safety analysis (Battelle Memorial Institute, 1970) indicates the welding procedure is essentially that of Section VIII, "Unfired Pressure Vessels," and Section IX, "Welding Qualifications" (ASME International, 1962b,c). Plate materials and filler materials referenced in the welding procedure are for Type 304 stainless steel. The tungsten inert gas or the shielded metal arc welding procedures are required by Battelle Memorial Institute procedures.

The conclusions drawn in this section of the confinement structures design criteria are based on the evaluation findings made in Section 4.1.3 of this SER. The staff concludes that the transfer cask design criteria and relevant codes and standards have been sufficiently described in accordance with 10 CFR §72.24(c), and §72.120(a).

<u>FPA Confinement Barrier</u>

As indicated in the SAR, two performance objectives for the FPA are:

- Prevent the release of radioactive materials to the environment during normal, off-normal, and accident conditions (important to safety function); and
- Provide a confinement barrier to permit safe handling of SNF during normal, off-normal, and accident conditions (important to safety function).

The reinforced concrete structures for the ISF Facility are designed in accordance with ultimate strength design methods specified in American Concrete Institute (ACI) 349-97 (American Concrete Institute, 1998). ACI 349-97 specifies the minimum requirements for the design and construction of nuclear safety-related concrete structures and structural elements for nuclear power generating stations. Additionally, the design criteria of the reinforced concrete structures

address site characteristics and environmental conditions under normal, off-normal, and accident conditions.

The design bases for the reinforced concrete structures of the FPA confinement boundary are identified in sufficient detail to demonstrate compliance with the general design criteria of 10 CFR Part 72, Subpart F. This conclusion also is supported by the structural review described in Section 5.1.1.4 of this SER. Design criteria for the reinforced concrete structures of the FPA confinement boundary have been shown in Chapter 4 of this SER to be representative of the site.

Additional items that compose the confinement barrier are designed to maintain integrity under normal, off-normal, and accident conditions. The design is to limit the annual dose to less than 10 mSv [1,000 mrem] at the confinement boundary. The shield windows are designed to withstand seismic activities, differential tornado pressure, and impact of tornado missiles. The HVAC ductwork and filters are designed in accordance with American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE), ASME International, and Sheet Metal and Air Conditioning Contractors' Association (SMACNA) criteria identified in Section 4.3.1.1 of the SAR. HEPA filters are specified as type B, nuclear grade and meet the requirements of ANSI/American Nuclear Society (ANS) N509 and ANSI N510 (American National Standards Institute/American Nuclear Society, 1989a,b). Design criteria for the personnel access door are based on the integrity of the confinement boundary given in Section 4.7.3.2.4 of the SAR. The port plugs are used to seal a variety of ports in the floor in the FPA during fuel transfers. These plugs are fabricated from steel and concrete with stepped sides for shielding and positive positioning. During transfer of the casks and canisters to and from the FPA through the ports, inflated seals are used to form part of the confinement boundary. These seals are designed to fail safe; upon a loss of power, the seal remains inflated.

The conclusions drawn in this section of the confinement structures design criteria are based on the evaluation findings made in Section 4.1.3 of this SER. The staff concludes the confinement structure design criteria and relevant codes and standards have been described sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

ISF Canister

The design codes for the ISF canister are provided in Sections 4.2.1.3 “ISF Canister;” 4.2.1.4, “ISF Canister Basket;” and 4.2.1.5, “ISF Canister Impact Plate and Shield Plug,” of the SAR. The ISF canisters are designed to survive normal, off-normal, and accident conditions with no significant radiological consequences to workers or the public. The storage structures and components of an ISF canister are designed and fabricated in accordance with recognized codes and standards that provide acceptable safety margins.

The ISF canister is designed in accordance with Subsection NB (Class 1 Components), Article NB–3000 (ASME International, 1998a). The ISF canister baskets that provide criticality control features are designed in accordance with Subsection NG (Core Support Structures), Article NG–3000. The ISF canister impact plate and shield plug are designed to the requirements of Subsection NF (Supports), Article NF–3000. The shield plug is part of the ISF basket handling load path and is designed to the requirements of Subsection NF (ASME International, 1998a).

The conclusions drawn in this section of the confinement structures design criteria are based on the evaluation findings made in Section 4.1.3 of this SER. The staff concludes the confinement structures design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c), and §72.120(a).

<u>ISF Storage Tube</u>

The design codes for the ISF storage tube are provided in Section 4.2.1.2, “Storage Tube Assembly,” of the SAR. The tubes are designed to survive normal, off-normal, and accident conditions with no significant radiological consequences to workers or the public. The storage structures and components are designed and fabricated in accordance with recognized codes and standards that provide acceptable safety margins.

The ISF storage tube pressure boundary components (confinement barrier) are an N-stamped Class 2 component in accordance with ASME International (1998a). The storage tube body, lid, bolts, and seals are designed in accordance with Subsection NC (Class 2 Components), Article NC–3000. The support stool, charge face encast, and the charge face cover plate are designed in accordance with the American Institute of Steel Construction (AISC) manual (American Institute of Steel Construction, 1989), and the weld design and specification are in accordance with American Welding Society (AWS) D1.1 (American Welding Society, 2002). The ISF storage tube plug is designed in accordance with the AISC manual and ACI 349-97 (American Concrete Institute, 1998). The tube plug lifting pintle and lifting adapter are designed in accordance with Crane Manufacturers Association of America (CMAA) Specification No. 70 (Crane Manufacturers Association of America, 1994).

The design parameters for the storage tube are:

- Design pressure: 344 kPa [50 psig];
- Design temperature: 149 °C [300 °F]; and
- Design basis leak rate: 10^{-4} cc/s.

The conclusions drawn in this section of the confinement structures design criteria are based on the evaluation findings made in Section 4.1.3 of this SER. The staff concludes that the confinement structure design criteria and relevant codes and standards have been described sufficiently in accordance with 10 CFR §72.24(c), and §72.120(a).

5.1.1.3 Material Properties for Confinement Structures

<u>U.S. Department of Energy Transfer Casks and Fuel Containers</u>

The structural components of the transfer casks and the various fuel baskets are made primarily of welded carbon and stainless steel. Material properties for confinement structures are presented in Section 4.7.3.3.1 of Appendix A of the SAR, the structural analysis report (U.S. Department of Energy–Idaho Operations Office, 2003), and the original transfer cask SAR (Battelle Memorial Institute, 1970) used as a basis for the original certification in accordance with 10 CFR Part 71. Transfer cask dimensions are provided in Appendix A of the SAR (Foster Wheeler Environmental Corporation, 2003a). Structural components of the transfer cask are constructed from American Iron and Steel Institute (AISI) 1025 carbon steel,

A-36 carbon steel, and Type 304 stainless steel. The cylindrical portion of the transfer cask is constructed using Type 304 stainless-steel inner barriers and an AISI 1025 carbon-steel outer barrier. A physical gap between the inner and outer barriers is filled with lead. The outer barrier is covered with a Type 304 stainless-steel skin. Bolted lids are used at each end of the transfer cask. An alternative lid has been fabricated for each of the two transfer casks for use in retrieving Peach Bottom Core 1 fuel baskets from CPP-749. One lid is fabricated from carbon steel and the other from stainless steel. American Society for Testing and Materials (ASTM) A-276, USN21800, (Nitronic 60) bolts will be used to secure the lid. Trunnions are constructed from Type 304 stainless steel welded to the AISI 1025 carbon-steel outer barrier. Quick disconnect fittings are located inside the trunnions to allow easy connection of instrumentation (Foster Wheeler Environmental Corporation, 2003a; Westinghouse Electric Corporation, 1986).

Fabrication of the transfer cask is described in Appendix A of the SAR and in the original SAR (Battelle Memorial Institute, 1970). Based on information in the original SAR, the Peach Bottom shipping casks were fabricated and inspected according to Battelle Memorial Institute procedures.

Material properties for the AISI 1025 A36 carbon steel and Type 304 stainless steel structural materials are provided in Chapter 2 of Battelle Memorial Institute (1970). Material properties for the Nitronic 60 bolts were provided in response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003c). Mechanical properties of the transfer cask materials including the inner Type 304 stainless steel barrier, outer carbon steel, lead shielding material, lid materials, and lid bolts are provided in the SAR for the Peach Bottom-2 cask (Westinghouse Electric Corporation, 1986). The staff independently verified the temperature-dependent values for the allowable stress, ultimate strength, yield strength, modulus of elasticity, and coefficient of thermal expansion. The staff concludes that these material properties are acceptable and appropriate for the expected load conditions during the license period.

Information provided by the applicant suggests the mechanical properties of AISI 1025 carbon steel are similar to the properties of A36 steel (Foster Wheeler Environmental Corporation, 2003c). Although A36 and AISI 1025 carbon steels have similar mechanical properties, AISI 1025 has a lower Mn content. The concentrations of Mn and C and the Mn-to-C ratio are known to influence the nil-ductility temperature of low carbon steels (Roe, 1978; Rinebolt and Harris, 1951). For the reported composition of AISI 1025 carbon steel, the ductile-to-brittle transition is expected to occur at temperatures of !7 EC [20 EF] or higher (Rinebolt and Harris, 1951). Using a 20-J [15-ft-lb] criteria, the nil-ductility temperature for AISI 1025 carbon steel could be greater than !30 EC [!22 EF]. The AISI 1025 carbon steel nil-ductility temperature may be !12 EC [9 EF]. Fabrication processes that increase grain size and result in segregation of P at grain boundaries also will increase the nil ductility temperature. Foster Wheeler Environmental Corporation will implement administrative controls to ensure that the transfer casks will not be handled (lifted) within the cask receipt area (CRA) following exposure to environmental conditions that could result in the temperature of the cask carbon steel shell dropping below !7 EC [20 EF]. Because of the external stainless steel skin, the cask carbon steel shell is not accessible for direct temperature measurement. However, if the combination of external temperature and cask transit time could result in the cask carbon steel shell dropping below !7 EC [20 EF], the cask will be held within the CRA for a sufficient time to

ensure that the cask carbon steel shell is warmed above !7 EC [20 EF] prior to beginning cask unloading operations.

Inner Container Material

Fuel elements from Peach Bottom Core 1 were placed in sealed aluminum canisters with stainless steel liners after removal from the reactor. After being transferred to the Idaho Nuclear Technology and Engineering Center (INTEC), an entire basket assembly loaded with fuel canisters was lowered into a below-grade drywell. While in storage at INTEC, some corrosion of the aluminum baskets has occurred. To transfer these fuel baskets, it is necessary to structurally reinforce the aluminum baskets. A new support plate was fabricated from ASTM A276 Types 304/304L stainless steel plate welded using ER308/308L AWS A5.9 filler metal. The support plate is connected to a Nitronic 60 rod that extends through the center tube of the basket. Design details are provided in Figures A–21 through A–24 of Appendix A of the SAR (Foster Wheeler Environmental Corporation, 2003a)

Peach Bottom Core 2 fuels are stored in irradiated fuel storage facility canisters constructed from either A53B carbon-steel pipe or Type 304L stainless-steel pipe. Because the Irradiated Fuel Storage Facility canisters containing the Core 2 fuel are not sealed and are smaller than the cask cavity, an inner liner and overpack must be provided for the onsite transfers. The inner liner is constructed from ASTM A187 Type 304 stainless steel. Design details are provided in Figures A–8 through A–10 of Appendix A of the SAR.

The Shippingport fuel and pieces, and irradiated reflector modules were placed in Type 304 stainless-steel storage canisters. The closure head is secured with twelve 2.54-cm-[1-in]-diameter bolts and sealed with a metallic o-ring gasket of silver-plated Inconel. Each closure bolt hole is sealed with a metallic o-ring. All components are constructed of Type 304 stainless steel. Design details are provided in Figures A–35 through A–37 of Appendix A of the SAR.

All stainless steel and aluminum clad TRIGA fuel will be packaged in a standard configuration consisting of a can, bucket, canister, and canister plug. The can, canister, and canister plug are constructed from Types 304/304L stainless steel and welded using ER308/308L AWS A5.9. The bucket is constructed from multiple 6061 aluminum alloys and welded using ER 4043 AWS A5.10 filler metal. An ASTM A187 Type 304 stainless steel inner liner and overpack will be used for the onsite transfers by DOE-ID. Design details are provided in Figures A–8, A–9, A–10, A–27, A–28, A–31, A–31A, and A–38 of Appendix A of the SAR.

Weld Materials

The materials of construction for the transfer cask and the interior containers are readily weldable using commonly available welding techniques. The transfer cask is constructed from AISI 1025 carbon steel, A36 carbon steel, and Type 304 stainless steel as specified in Appendix A of the SAR and Battelle Memorial Institute (1970). Information on the structural welds for the Peach Bottom transfer casks is provided in Appendix A of the SAR (Foster Wheeler Environmental Corporation, 2003a), Battelle Memorial Institute (1970), and the response to the staff’s request for additional information (Foster Wheeler Environmental Corporation, 2003b).

The Battelle Memorial Institute Welding Procedure for Cask Construction describes the welding of austenitic stainless steel and clad stainless steel by the shielded metal arc process and the tungsten inert gas process (Battelle Memorial Institute, 1970). The welding processes were essentially those of the ASME Section VIII (Unfired Pressure Vessel) and Section IX (Welding Qualifications) (ASME International, 1962c).

The original SAR does not address welding of the carbon-steel outer barrier. The six weld specifications listed in Note 7 in Figure A–5 of Appendix A of the SAR cannot be located. Based on a survey of industry professionals, Foster Wheeler Environmental Corporation (2003c) reported it is likely the welding processes used in the original carbon-steel outer barrier were either shielded metal arc or submerged arc processes. Because the outer barrier thickness is 38.1 mm [1.5 in], no postweld heat treatment would be required if 93 EC [200 EF] preheat was used in the welding processes. Based on the use of acceptable industry practice at the time of construction, it is assumed that either a preheat of 93 EC [200 EF] or postweld heat treatment was performed.

Inspection of the welds for the transfer cask was specified as either x-ray or liquid penetrant inspection. Foster Wheeler Environmental Corporation (2003c) has tabulated the types of likely nondestructive examination methods performed on the Peach Bottom transfer casks. With the exception of the carbon steel outer shell, all welds were likely inspected using visual inspection and liquid penetrant inspection. Trunnion welds were not subjected to volumetric examination (Foster Wheeler Environmental Corporation, 2003c). Records of the nondestructive examinations identified in the design drawings are not available. To address the lack of information discussed in this and the previous paragraphs, drop analyses for various drop heights were performed by the applicant. The staff determined that the transfer cask can perform safely as a containment barrier during postulated drop events.

Defects in the trunnion welds, including hot cracks, lack of fusion, and slag inclusions, have been identified using liquid penetrant inspection and repaired during preventative maintenance. The staff finds surface examinations of the root and final passes are insufficient to verify the integrity of the trunnion welds. As indicated by the DOE-ID, volumetric inspection of the trunnion welds for the transfer casks is not possible. Consequently, a drop analysis of the transfer casks onto a trailer was performed by the applicant to demonstrate that the transfer cask can maintain its confinement as a result of failure of the trunnion welds. The staff's review of this drop analysis is discussed in Section 5.1.1.4 of this SER.

Welding of the interior containers is documented in the SAR. Welding procedures, filler metals, inspection methods, and criteria are provided in the design drawings of the specific components. The Peach Bottom Core 1 support plate welding specifications are listed in Figures A–21 through A–24 of Appendix A of the SAR. Welding is performed using Idaho National Engineering and Environmental Laboratory (INEEL) weld procedure specification S2.24 or AWS D1.1 (American Welding Society, 2002). All welds are visually inspected in accordance with AWS D1.1.

The inner liner and overpack for transfer of the Peach Bottom Core 2 and TRIGA fuels are listed in Figures A–8 through A–10 of Appendix A of the SAR. Welding is performed using INEEL weld procedure specification S2.24. All welds are visually inspected in accordance with INEEL technical procedure TPR–4981 and acceptance criteria according to Appendix D. Stainless steel storage canisters for Shippingport fuel and pieces, and irradiated reflector

modules are shown in Figures A–35 through A–37 of Appendix A of the SAR. These containers are presently in use. After transfer, the fuel, fuel pieces, and reflector modules will be repackaged in ISF canisters and placed in storage tubes.

Material Coatings

The transfer casks and original top and bottom lids have exposed surfaces of stainless steel and are not coated. The original transfer cask bolts also are not coated. The new A36 carbon-steel lid is coated with Keeler & Long white epoxy paint No. 3500, which is Kolor-Poxy Self-Priming Surfacing Enamel. This coating is classified as a protective coating system for nuclear power plants Service Levels II and III, and balance of plant. The Keeler & Long technical datasheet for the No. 3500 Kolor-Poxy Self-Priming Surfacing Enamel identifies the temperature resistance is 177 EC [350 EF]. Thus, the coating is compatible with exposure temperatures in the range !34 EC [!30 EF] to 73 EC [163 EF] (Foster Wheeler Environmental Corporation, 2003c). Compatibility of the coating with borated water is not applicable because all fuel transfers are dry operations.

Material, Chemical, and Galvanic Reactions

Loading of fuel and reactor components at the proposed ISF Facility will be dry operations. The only sources of water on the transfer casks are condensation or precipitation. Foster Wheeler Environmental Corporation (2003c) has indicated that moisture would be wiped prior to removing the cask from the transport trailer. Decontamination of the cask is described in Section 4.4.1.1 of the SAR. The moisture would contact the Type 304 stainless steel outer cover. Because the water composition is expected to be low conductivity and in contact with essentially only stainless steel, galvanic reactions that could cause corrosion damage are not expected.

Because of the age of the transfer cask, complete documentation of the materials used in its construction is not available. Based on the review of information presented in the SAR and subsequent transmittals, the staff concludes materials have been described adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified adequately the appropriate code and standards in accordance with 10 CFR §72.24(c)(4).

<u>FPA Confinement Barrier</u>

The staff reviewed the materials of construction of the ISF Facility FPA confinement boundary. Material selection is based on concrete with a compressive strength of 27.6 MPa [4,000 psi] following Chapter 5 of ACI 349-97 (American Concrete Institute, 1998). The reinforcing steel is specified to have a minimum yield strength of 414 MPa [60,000 psi] following Chapter 3 of ACI 349-97 (American Concrete Institute, 1998) and ASTM standard (American Society for Testing and Materials, 2000).

Details of the materials of construction for the other components (shield windows, sealed wall penetrations, HEPA filters and portions of HVAC ductwork, personnel shielded access door into the FHM maintenance area, FHM maintenance area hoist well, port plugs located in the floor of the FPA, inflatable seals at the canister and cask ports) are not identified. These components are to be designed in accordance with the appropriate codes and standards.

Based on the review of information presented in the SAR, the staff concludes materials to be used to construct the FPA confinement boundary have been described adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified adequately the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

ISF Canister

The ISF canister is fabricated and inspected in accordance with the ASME Subsection NB (Class 1 Components) (ASME International, 1998a). The ISF canister basket is fabricated and inspected in accordance with the ISF Facility Quality Program Plan using ASME Subsection NG (Core Support Structures) as guidance. The ISF canister impact plate and shield plug are fabricated and inspected in accordance with the ISF Facility Quality Program Plan, using ASME Subsection NF (Supports) as guidance.

The ISF canister assembly is fabricated from the following materials:

- Canister body: ASME SA312, Type 316L;
- Upper and lower heads: ASME SA240, Type 316L;
- Upper and lower impact plates: ASME SA240, Type 316L, or ASME SA351, CF3M, or CF3MN;
- Impact plate retaining ring: ASME SA240, Type 316L;
- Shield plug retaining ring: ASME SA240, Type 316L, or ASME SA479, Type 316L;
- Upper and lower impact limiter: ASME SA312, Type 316L;
- Upper and lower lifting ring: ASME SA240, Type 316L; and
- Canister stainless steel components are left uncoated.

The canister shield plug is fabricated from the following materials:

- Lifting pintle: ASME SA479, Type 316L;
- Shield plug: ASME SA479, Type316L or ASME SA351, CF3M, or CF3MN;
- Spacer: ASME SA312, Type 316L; and
- Dowel pin: ASME SA479, Type 316L.

The Peach Bottom ISF baskets are fabricated from the following materials:

- Lid, locking plate, base plate (attached removal tool), and top plate (attached removal tool): ASME SA240, Type 316L;
- Lifting pintle: ASME SA479, Type 316L;
- Spacer plate, base plate, and top plate: ASME SA693, Type 630 (17-4 Ph);
- Tie bar, lid securing pin, and special screw: ASME SA564, Type 630 (17-4 Ph);
- Fuel tube: ASME SA213, Type 316L;
- Gadolinium phosphate container tube: ASME SA213, Type 316L; and
- Repository neutron absorber material: gadolinium phosphate.

The TRIGA ISF baskets are fabricated from the following materials:

- Lid and locking plate: ASME SA240, Type 316L;
- Lifting pintle: ASME SA479, Type 316L;

- Spacer plate, base plate, and top plate: ASME SA693, Type 630 (17-4 Ph);
- Compressive tie bar, lid support pin, and special screw: ASME SA564, Type 630 (17-4 Ph);
- Lid securing rod: ASME SA479, Type 316L;
- Fuel tube: ASME SA213, Type 316L;
- Spacer: ASME SA312, Type 316L;
- Gadolinium phosphate container tube: ASME SA213, Type 316L; and
- Repository neutron absorber material: gadolinium phosphate.

The Shippingport reflector IV module ISF baskets are fabricated from the following materials:

- Extruded aluminum guide rails: ASTM SB211, Alloy 6061 T6;
- Spacer plates: ASME SA240, Type 316L;
- Machine screws: ASME B18.6.3, Type B8M; and
- Load distribution base plate: ASME SA240, Type 316L and ASME SA312, Type 316L.

The Shippingport reflector V module ISF baskets are fabricated from the following materials:

- Guide rails: ASME SA240, Type 316L;
- End and intermediate plates: ASME SA240, Type 316L;
- Tie rods: ASME SA479, Type 316L;
- Tie rod support tubes: ASME SA213, Type 316L;
- Machine screws: ASME B18.6.3 type B8M; and
- Load distribution base plate: ASME SA240, Type 316L and ASME SA312, Type 316L.

The Shippingport reflector rod ISF baskets are fabricated from the following materials:

- Lid and locking plate: ASME SA240, Type 316L;
- Lifting pintle: ASME SA479, Type 316L;
- Tie bar, lid securing pin, and special screw: ASME SA564, Type 630 (17-4 Ph);
- Spacer plate, base plate, and top plate: ASME SA693, Type 630 (17-4 Ph); and
- Fuel tubes: ASME SA213, Type 316L.

Note that no gadolinium-absorber material is required for the Shippingport reflector baskets to satisfy their safety function.

Coatings are not used for corrosion protection of the ISF basket assembly materials.

Based on the material reviewed, the staff concludes the following:

- The selection of these materials is acceptable for the ISF canister.
- The welded joints of the ISF canister meet the requirements of the ASME standards (ASME International, 1998a), as applicable.
- The material stress intensity limits are acceptable and appropriate for the expected load conditions during the license period.
- The material selection for the ISF canister meets the requirements of the ASME standards, as applicable.

The ISF canister materials and fabrication procedures have been described sufficiently in accordance with 10 CFR §72.24(c)(3) and §72.120(a).

<u>ISF Storage Tube</u>

The storage tube body, lid, bolts, and seals are fabricated and inspected in accordance with the ASME Subsection NC (Class 2 Components). The support stool, charge face encast, and the charge face cover plate are fabricated and inspected in accordance with the AISC manual (American Institute of Steel Construction, 1989), and the welding is performed and inspected in accordance with AWS D1.1. The aluminum spray coating is used to prevent corrosion of the storage tube external surface as indicated in Section 4.2.3.3.8 of the SAR. The ISF storage tube plug is fabricated and inspected in accordance with the AISC manual and ACI 349 (American Concrete Institute, 1998). The tube plug lifting pintle and the tube plug lifting adapter are fabricated and inspected in accordance with CMAA Specification No. 70 (Crane Manufacturers Association of America, 1994).

Materials of construction are provided for the storage tube assembly, support stool, charge face encast, and charge face cover plate. The storage tube assembly is fabricated from the following materials:

- Storage tube body: ASME SA333 Grade 6;
- Storage tube top forging: ASME SA350 Grade LF2;
- Storage tube flat closure plate: ASME SA350 Grade LF2;
- Storage tube lid: ASME SA516 Grade 55;
- Storage tube lid cap screws: ASME SA193 Grade B7;
- Storage tube lid cover plate: ASME SA516 Grade 55;
- Storage tube lid cover plate cap screws: ASME SA193 Grade B7;
- Metal seal rings: Inconel Alloy 718, silver plated;
- Storage tube plug body: ASTM A333 Grade 6 and ASTM A36;
- Storage tube plug concrete fill: minimum density 2,243 kg/m^3 [140 lb/ft^3];
- Lifting pintle: ASTM A434 Grade 4340 Class BC;
- Storage tube and lid external surface coating: aluminum spray; and
- Storage tube and lid internal surface coating: etch primer.

The charge face cover plate is made from the following materials:

- Charge face cover plate: ASTM A36;
- Charge face cover plate cap screws: ANSI B18.3, ASTM A574; and
- Charge face cover plate coating: two-part epoxy paint.

The charge face encasts are made from the following materials:

- Encast pipe sections: ASTM A333 Grade 1;
- Encast plate and bar sections: ASTM A36;
- Charge face encast internal surface coating: aluminum spray; and
- Surfaces of encast in contact with concrete: primer coated.

The support stool assembly is made from the following materials:

- Support stool plate sections: ASTM A572 Grade 42, Type 1;
- Support stool alignment guides: ASTM A6, ASTM A572 Grade 42, Type 1;
- Support stool anchor bolts: ASTM A193, Grade B7;
- Support stool external surface coating: aluminum spray; and
- Support of support stool in contact with grout: paint with primer.

Based on the material reviewed, the staff concludes that:

- The selection of these materials is acceptable for the ISF storage tube;
- The welded joints of the ISF storage tube meet the requirements of the ASME standards (ASME International, 1998a), as applicable;
- The material stress intensity limits are acceptable and appropriate for the expected load conditions during the license period; and
- The material selection for the ISF storage tube meets the requirements of the ASME standards, as applicable.

The ISF storage tube materials and fabrication procedures have been identified in accordance with 10 CFR §72.24(c)(3) and §72.120(a).

5.1.1.4 Structural Analysis for Confinement Structures

U.S. Department of Energy Transfer Casks and Fuel Containers

The staff reviewed the analysis report of corner drop accident scenarios for the transfer casks (U.S. Department of Energy–Idaho Operations Office, 2003). The applicant has clarified (Foster Wheeler Environmental Corporation, 2003c) that DOE-ID will use “bolts made from ASTM A276 bar stock (Nitronic 60) for all cask configurations” and the analysis is based on this bolt material. The staff also reviewed the response to the staff’s request for additional information (Foster Wheeler Environmental Corporation, 2003c). This report also evaluates the end and side drop conditions for various drop heights.

The staff finds that these drop analyses reports show the transfer casks will remain sealed and, thus, perform safely as a containment barrier during postulated drop events. Simulations demonstrate that the transfer casks meet the requirements of 10 CFR §72.122(b) with one exception. Because volumetric inspection of the trunnion welds has not been performed and weld integrity cannot be assumed, a drop analysis was conducted to demonstrate that the transfer cask will perform safely when dropped onto the transport trailer.

The applicant provided a supplemental analysis of the cask and trunnion structure during lift (Foster Wheeler Environmental Corporation, 2004). This analysis used an elasto-plastic approach to demonstrate that the shell and trunnion structure of the transfer cask are designed to meet a factor of safety of 10 with respect to ultimate strength.

The staff has made an independent assessment of the cask and trunnion structure based on the finite element model presented by the applicant. The staff used a common elastic analysis

approach, which confirms the applicant's conclusion that the cask and trunnion structures satisfy the ultimate strength requirements of NUREG–0612.

An analysis of transfer cask drop onto the transport trailer was also performed by the applicant (Foster Wheeler Environmental Corporation, 2004). This analysis is required because trunnion weld integrity cannot be fully assured for lack of volumetric weld inspection. The conclusions drawn in the applicant's drop analysis are that the thickness of the lid is sufficient to prevent puncture in that location and that the geometry of the cask is such that a puncture of the cask cannot reach the inner cylinder. Therefore, the confinement of the transfer cask is not impaired by a drop onto the transport trailer. The staff does not agree with the specific equations used by the applicant in its drop analysis; however, based on its own independent analysis of lid puncture, the staff reaches the same conclusion as the applicant that the confinement function of the transfer cask is not impaired.

The cask trunnions, as interface lifting points, meet the single-failure-proof design requirements. The transfer cask structural and drop analyses provided by the applicant are sufficient to satisfy the safety requirements of 10 CFR §72.122(b).

<u>FPA Confinement Barrier</u>

As indicated in Section 4.7.3.3.2 of the SAR, the structural analysis of the transfer area was performed to demonstrate the structural adequacy of the concrete important to safety structures in accordance with the design loads and combinations. The structural analysis methodology included static and response spectra methods. The finite element analysis program SAP2000 (Computers and Structures Inc., 2000) was used to model and analyze the transfer area. The steel structure not important to safety that surrounds the FPA was included in the finite element model of the transfer area specifically for its effect on the concrete structure. Similar design basis loads were applied to the primary steel structure not important to safety as to the concrete structure important to safety, including seismic and tornadic wind.

The structural analysis of the FPA confinement barrier is provided in several calculation packages as part of the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b). The calculation packages reviewed include:

- ISF–FW–CALC–0130, Transfer Area–Fuel Packaging Area. Steady-State Thermal Analysis of Peach Bottom, TRIGA, and Shippingport Reflector IV (Loose Rods and Module) Fuel Types;
- ISF–FW–CALC–0303, Personnel Shielded Access Door Structural Calculation;
- ISF–FW–CALC–0321, Transfer Area Finite Element Structural Analysis Static and Seismic Load Cases;
- ISF–FW–CALC–0323, Transfer Area Overturning and Sliding Evaluation;
- ISF–FW–CALC–0324, Transfer Area–Loads and Masses for Finite Element Model;
- ISF–FW–CALC–0325, Concrete Temperatures for Thermal Stress Analysis–Transfer Area;
- ISF–FW–CALC–0327, Transfer Area–Design of Concrete Walls and Columns;
- ISF–FW–CALC–0375, Shield Window Resistance to Tornado Missiles; and
- ISF–FW–CALC–0539, Transfer Area and Storage Area Concrete Thermal Analysis.

The mathematical model developed for the transfer area building structures was generated in accordance with requirements addressed in American Society of Civil Engineers (ASCE) 4-98 (American Society of Civil Engineers, 1998) and Regulatory Guide 1.92 (U.S. Nuclear Regulatory Commission, 1976). The reinforced concrete walls, slabs, and foundation mats were simulated by SAP2000 using shell elements. Stiffness of reinforced concrete elements was modeled using concrete material properties and the gross thickness of the element. Structural analysis results are reported as nodal, element forces and moments, or both, which were then used for member structural design. Other linear elements use the SAP2000 frame element. The SAP2000 program includes a structural section library for rolled steel sections contained in the AISC manual (American Institute of Steel Construction, 1989). This library provides an accurate call out of the steel section properties used in the model. Nodes were located to capture true geometric properties and configurations, attain regular shell mesh shapes and aspect ratios, and locate dominant point masses.

Major equipment including the FHM crane in the FPA was explicitly modeled with the building structure. Significant masses of other equipment were applied at designated locations and positioned to capture the most critical dynamic effects on the supporting structure.

The static load cases for the transfer area structure include dead, live, wind, and pressure loads. They are combined linearly with the multisolution response spectra seismic case. A separate finite element analysis was performed to evaluate thermal response of the transfer area because different boundary conditions were required. Thermal effects because of changes in material temperature from the reference temperature (assumed stress free) to a final steady-state temperature were captured in this analysis. The effect of the temperature gradient across the shell thickness was also included in the thermal analysis. A complete review of the thermal analysis is contained in Chapter 6 of this SER.

The time history soil-structure interaction analysis described in Section 3.2.3.1.8 of the SAR was performed to investigate the soil-structure interaction effects and to develop in-structure response spectra for the transfer area. The soil-structure interaction analysis was used to identify response spectra across the base of the transfer area. An envelope of the spectra was used as input to a structural model of the FPA but had a “rigid” foundation mat. The model of the FPA was used to develop in-structure response spectra for the FPA. Modal response characteristics were evaluated, and the fundamental frequencies in three global directions were noted. More than 90 percent of the building mass was accounted for in the horizontal direction and 89 percent in the vertical direction, which meets the requirements of ASCE 4-98 (American Society of Civil Engineers, 1998) and Regulatory Guide 1.92 (U.S. Nuclear Regulatory Commission, 1976). Structural analyses of the combined steel and reinforced concrete structures under seismic loads were performed using the response spectra method. The method of combining modal responses and spatial (X, Y, Z) components are in accordance with the guidelines of Regulatory Guide 1.92. The value for structural damping was taken from Regulatory Guide 1.61 (U.S. Nuclear Regulatory Commission, 1973).

Enveloping load cases were formulated to evaluate the structural demands on the reinforced concrete components. Preliminary member sizing was based on the enveloping load cases defined next. Portions of the structure were evaluated more rigorously by evaluating individual load cases. Walls and slabs were designed for axial, flexural, and shear forces in the sections. The input forces and moments for each wall or slab were taken from the contour plots of the shell element forces and moments from the enveloped load cases. The reinforcement used in

determining the concrete capacity was calculated based on the requirements of ACI 349-97 (American Concrete Institute, 1998).

The thickness of the walls is based on radiological shielding requirements. Table 4.7-15 of the SAR provides a summary of the capacity-to-demand ratios for various wall sections in the transfer area (based on ACI 349-97 code requirements). The concrete design forces and moments are dominated by the results of the thermal load analysis.

The transfer area concrete building is supported on a mat foundation. The mat thickness in the Transfer Tunnel and at grade are 1.22 and 1.52 m [4 and 5 ft], respectively. Actual steel requirements vary throughout the mats, depending on the magnitude of the bending moments and shear forces in the mat. The capacity-to-demand ratios for the mat foundations caused by flexure and shear are shown in Table 4.7-10 of the SAR. These ratios are conservative considering demand is based on an envelope of the load combinations. The minimum capacity-to-demand ratio for sliding in the east-west direction is 1.26, based on seismic loading. The minimum ratio of 5.5 for overturning in the east-west direction also is based on the seismic loads. In the north-south direction, the seismic load-controlled sliding and overturning have capacity-to-demand ratios of 1.87 and 4.2. These results are shown in Table 4.7-14 of the SAR. These ratios are greater than the minimum allowable ratio of 1.1.

The reinforced concrete slabs and beams were designed based on demands caused by axial, flexure, and shear forces for each main section. The thickness of the slabs is based on radiological shielding requirements. Table 4.7-17 of the SAR provides a summary of capacity-to-demand ratios for various slabs and beams in the transfer area (based on ACI 349-97 code requirements). The concrete design forces and moments are dominated by the results of the thermal load analysis.

The shield windows have been evaluated to demonstrate that they can withstand accident events. The shield window set is also designed for the temperature differentials that could occur between the inside of the FPA and the operating galley during normal, off-normal, and accident conditions.

The HVAC system is not required to operate during design basis accidents. Portions of the system passively ensure that the confinement barriers of the FPA and FHM maintenance area are maintained during off-normal and accident conditions. HVAC ductwork that penetrates the confinement barrier of the FPA and FHM maintenance area provides a minimum 1-hour fire barrier to prevent fires outside the confinement barrier from spreading into the FPA or FHM maintenance area. The HVAC system is not required to mitigate the effects of a design basis tornado. Portions of the HVAC system provide a confinement barrier for the FPA and FHM maintenance area, however. The HVAC ducts penetrating this boundary are provided with spring-actuated tornado dampers designed to activate at a differential pressure exceeding normal operating values and to seal properly up to a differential pressure of 10.3 kPa [1.5 psi] according to Regulatory Guide 1.76 (U.S. Nuclear Regulatory Commission, 1974). The FPA supply tornado damper meets ASME International AG–1 gas-tight criteria. The HVAC system is not required to function during or after a seismic event. Portions of the HVAC system that perform confinement barrier functions are designed to withstand the effects of the design basis earthquake (DBE). Ductwork considered important to safety is designed to survive the effects of a design basis accident and continue to perform its required important to safety function. A breakaway joint is provided at the interface between the ductwork important to safety and the

ductwork not important to safety to protect the important to safety ductwork. The portions of the HVAC system that form a confinement barrier are above the maximum probable flood elevation. Therefore, the FPA and FHM maintenance area are protected from a design basis flood by the supply HEPA filters and in-cell exhaust HEPA filters.

The staff accepts the ultimate strength design method as presented in the ACI 349-97 (American Concrete Institute, 1998) for concrete structures important to safety. The FPA confinement boundary important to safety was analyzed for normal, off-normal, and accident loading conditions. This analysis was conducted to ensure the FPA confinement boundary important to safety would be able to perform the intended safety functions during the extreme environmental and natural phenomena as specified in 10 CFR §72.122(b)(1) and (b)(2) and in ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992).

The staff reviewed the SAR and finds that the structural analysis procedures have been properly identified and are in conformance with standard engineering practice as described in ACI 349-97 (American Concrete Institute, 1998). The relationship between the design criteria, identified in Chapter 3 of the SAR, and the analysis procedures was 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 also have been identified in the SAR in accordance with the requirements of 10 CFR §72.24(c)(4).

ISF Canister

The detailed structural analysis of ISF canister structures is presented in Sections 4.2.3.3.1, "ISF Canister Structural Evaluation," and 4.2.3.3.2, "ISF Canister Internals Structural Evaluation," of the SAR. These SAR sections are a summary of the structural evaluation performed in numerous calculations. The structural analysis of the ISF canister is provided in several calculation packages as part of the responses to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b). They are:

- ISF–FW–CALC–0357, Structural Evaluation of the Peach Bottom 45.7-cm [18-in] Canister;
- ISF–FW–CALC–0358, Structural Evaluation of 45.7-cm [18-in] TRIGA Canister; and
- ISF–FW–CALC–0359, Structural Evaluation of Shippingport 61.0-cm [24-in] Canister

As documented, the structural analysis shows that the structural integrity of the ISF canister is maintained for all credible loads. Based on the results presented in the SAR, the stresses in the ISF canister, even with the most critical load combinations, are less than the stress intensity limits of ASME Section III (ASME International, 1998c) for the ISF canister materials.

The design loadings (established in accordance with ASME NCA–2142.1) for the ISF canisters are as follows. The canister pressure boundary is evaluated using the acceptance criteria of ASME standard, Section III, Subsection NB. The normal condition loadings are considered as those required to satisfy Level A service limits. The off-normal and accident condition loadings are evaluated against Level B and Level D service limits. Table 4.2-7 of the SAR defines the loading combinations for the pressure-retaining portions of the canister that have been used in the stress analyses to ensure conformance with appropriate ASME code requirements.

The canisters are designed to withstand the static loads caused by their own weight and the weight of internal components (e.g., basket, SNF, shield plug, and impact plates). The weights of vacuum drying and seal welding equipment attached to the upper dome also have been considered. The weights considered are the maximum canister weights in Table 4.2-6 of the SAR.

For the ISF canisters, the internal design pressure has been set conservatively to 345 kPa [50 psig], which envelopes the normal, off-normal, and accident internal pressure loadings by a large margin. The initial fill pressure is nominally 41 to 48 kPa [6 to 7 psig]. No significant increase in pressure results from the 1-percent failed fuel rods. For the structural evaluation of the canisters, a full vacuum at 101 kPa [14.7 psi] (at mean sea level) inside the canister has been assumed.

The minimum and maximum service temperatures for the ISF canisters have been determined from thermal analyses of a combined model of the canister and storage tube with the appropriate SNF heat generation rate and the maximum and minimum temperatures of air entering through the storage vault inlet air vents. Although the minimum and maximum normal air temperatures are !32 EC and 37 EC [!26 EF and 98 EF], the off-normal minimum !40 EC [!40 EF] and maximum 38 EC [101 EF] have been used in the thermal calculation. The maximum Level A temperature during storage inside the storage tubes is not expected to exceed 54 EC [129 EF]. The design temperature for the ISF canisters has been conservatively set to 343 EC [650 EF].

The canister and basket materials have identical coefficients of thermal expansion, and the canister and its internals are free to expand; therefore, the thermal stresses resulting from the normal service temperatures are insignificant.

For the vertical lifts of the fully loaded canisters, the dead-weight loads have been increased by 15 percent to include dynamic effects from lifting operations, as recommended by CMAA No. 70 (Crane Manufacturers Association of America, 1994). The ISF canister lifting rings and the impact absorbers meet the requirements of ANSI N14.6 (American National Standards Institute/ American Nuclear Society, 1993) as applicable to a critical load.

The following nonmechanistic drops were considered:

- The canister drops back into the canister cask on the canister trolley
- The canister drops onto the charge face in the storage area
- The canister drops into the storage tube

The last case is the critical case that has the maximum drop height; it has been considered as a nonmechanistic drop in the canister and storage tube structural analysis.

The seismic analyses of the ISF canisters use equivalent static acceleration loads based on the guidance provided by NUREG–0800, Section 3.7.2 (U.S. Nuclear Regulatory Commission, 1996). The ANSYS (ANSYS Inc., 2001) models used for structural analyses include the gaps between the basket and canister, canister and storage tube, and between storage tube and the storage tube lateral supports. A modal analysis was performed to determine the modal frequencies of the system to establish conservative values of seismic accelerations. These

values are to be used in the structural evaluation of the ISF canisters and storage tubes for earthquake-induced loading using equivalent static analysis methodology.

The dominant horizontal mode for the Peach Bottom, TRIGA, and Shippingport canisters lies between 0.37 and 0.57 Hz. The effective mass in this mode is more than 95 percent of the total mass. At these low frequencies, the horizontal acceleration [from 4-percent damping spectra (Figures 3.2-44 and 3.2-45 of the SAR)] is less than 0.25g. The horizontal acceleration considered in the seismic evaluation of the canisters and storage tubes has been conservatively calculated using the square root sum of the squares combination of 150 percent of peaks of the two horizontal spectra. The resulting acceleration was further amplified by a factor of 1.10. This process results in an amplification by a factor of 1.87 based on the peak acceleration and by a factor of 16.52 based on the acceleration at the dominant frequency. In the vertical direction, the dominant frequency varies between 67.8 and 110.9 Hz, indicating that the canister and storage tube behave in a rigid mode for this direction. Therefore, the zero period acceleration may be applied in the vertical direction. The actual value used in the seismic analyses is 0.32g, which is the vertical zero period acceleration further amplified by a factor of 1.10. The structural responses to horizontal and vertical seismic accelerations are combined by the square root sum of the squares method.

For design and service conditions, the stresses within the canister pressure boundary must comply with ASME Subsection NB stress limits. The stress intensity limits for each of the service levels are calculated using the criteria listed in Table 4.2-8 of the SAR, and the material mechanical properties for each of the ISF canister materials are provided in Table 4.2-9 of the SAR. The stress intensity limits for the canister materials are detailed in Table 4.2-10 of the SAR. In accordance with the ASME Code Case N-595-2 requirement (ASME International, 1998c), allowable stress intensity limits for the final closure weld are reduced by a factor of 0.70, although the weld examination will be performed by both ultrasonic and liquid penetrant methods.

An ANSYS (ANSYS Inc., 2001) finite-element stress analysis was performed to demonstrate structural adequacy and code compliance for applicable loading conditions postulated to occur at the ISF Facility during interim storage of the SNF loaded canisters. The ANSYS finite element model included the canister, the canister internals, and the storage tube modeled with three-dimensional solid elements. Figure 4.2-24 of the SAR shows the finite element model of the canister assembly. The gap between the inside surface of the storage tube and the outside surface of the canister was represented by node-to-node contact elements to allow prediction of any canister tipover during lateral seismic loading. The canister is free standing inside the storage tube, and the contact elements between the top of the storage tube bottom plate and the canister bottom allow any uplift and tipover of the canister, but support it for vertically downward loading. The impact plates were modeled by solid elements with surface-to-surface contact elements representing the contact surfaces between the canister domed head and the impact plate. The baskets were modeled using radial and vertical beam elements and lumped masses. A small gap between the radial beam and the inner surface of the canister allowed the basket to slide during lateral loading. The shield plug also was modeled as a lumped mass positioned at the top of the basket, except for the Shippingport reflector IV and V module ISF canisters. For these canisters, the shield plug and the support ring also are modeled using solid elements.

For the nonmechanistic drop of a canister into a storage tube, an elastic-plastic analysis of the canister was performed to assess the change in geometry and to obtain the stress-strain response. The drop analysis was performed using LS-DYNA (Livermore Software Technology Corp., 2001) with the previous ANSYS model modified to generate a quarter model sufficient to analyze this case. As a consequence of the drop, the lower impact absorber, lower dome, lower lifting ring, and a portion of the storage tube undergo plastic deformation. The elastic-plastic analysis was based on the kinematic hardening material model and the bilinear stress-strain behavior of the component materials.

The calculated stresses for the canister pressure boundary components and the design margins are detailed in Tables 4.2-11, 4.2-12, and 4.2-16 through 4.2.43 of the SAR. These tables show each of the canister types with respect to the service level loadings. Design margin is defined as the ASME code (ASME International, 1998c) stress intensity limits divided by the actual calculated stress, minus one. A net positive design margin is required to demonstrate compliance to the code stress intensity limits. The ISF canister confinement structure and internals analysis have demonstrated compliance with 10 CFR §72.24(a) and (d); §72.122(b), (c), and (h); and §72.128(a).

<u>ISF Storage Tube</u>

The detailed structural analysis of the ISF storage tube is presented in Section 4.2.3.3.3, " Storage Tube Assembly Structural Evaluation," of the SAR. The SAR section is a summary of the structural evaluations performed in numerous calculations. The structural analysis of the ISF storage tube is provided in the following calculation packages as part of the responses to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0368, Structural Evaluation of the 18-in Storage Tube Assembly, and
- ISF–FW–CALC–0369, Structural Evaluation of the 24-in Storage Tube Assembly.

As documented, the structural analysis shows that structural integrity of the ISF storage tubes is maintained for all credible loads. Based on the results presented in the SAR, the stresses in the ISF storage tube for the most critical load combinations are less than the stress intensity limits of ASME Section II (ASME International, 1998c) for the ISF storage tube materials.

The pressure boundary components of the storage tube assembly are classified important to safety as they provide the secondary confinement barrier for the SNF during normal, off-normal, and accident conditions. The pressure boundary components of the storage tube assembly are N-stamped as an ASME Subsection NC, Class 2 vessel (ASME International, 1998a). The pressure boundary consists of the tube body (with welded forged base plate and tube top) and the storage tube lid.

The structural evaluation of the storage tube assembly is performed using ANSYS/Mechanical Version 5.7 (ANSYS Inc., 2001) and ANSYS/LS-DYNA Version 5.7 (Livermore Software Technology Corp., 2001) finite element analysis software and hand calculations. Structural analyses are performed by elastic-plastic analysis methods to demonstrate the structural adequacy and code compliance for applicable loading conditions postulated at the ISF Facility. The ANSYS model includes the lower tube, forged base plate, support stool plate and alignment tees, and a simplified canister as shown in Figure 4.2-25 of the SAR. The total

canister weight, including that of the loaded SNF basket and impact plates, is included as an increase in the modeled density of the canister material property.

The storage tube and simplified canister are modeled using the three-dimensional solid element. The gap between the inside surface of the storage tube and the outside surface of the canister is represented by the three-dimensional node-to-node contact element. The canister is freestanding inside the storage tube. The node-to-node contact between the canister bottom and the storage tube bottom plate allows the canister to uplift and tip, but be supported during compressive loading.

Constraints for the storage tube include models of the charge face liner support pads and the support stool. The charge face liner support pads are modeled as constrained nodes. Node-to-node contact elements are modeled between these nodes and nodes on the outer radius of the upper storage tube annular forging. The storage tube is freestanding on the support stool. The support stool, including the support plate and alignment tees, also is modeled with constrained nodes. The support plate constrained nodes are offset vertically from the nodes making up the bottom surface of the storage tube bottom forged plate. Node-to-node contact elements between the storage tube bottom plate and the support stool plate allow the storage tube and its contents to uplift and tip, but be supported during compressive loading. Node-to-node gap elements are provided between the bottom outer radius of the storage tube and the support stool alignment tees.

The drop analysis is performed using ANSYS/LS-DYNA Version 5.7 A (Livermore Software Technology Corp., 2001), a software package that contains ANSYS (ANSYS Inc., 2001) for pre- and post-processing, and an explicit code, DYNA3D. For the postulated vertical drop of the tube plug in the storage tube, a quarter-symmetry model is necessary. The ANSYS model described previously is modified to function properly within LS-DYNA. Node sets are defined in the input file for the surfaces in contact. Contact elements are generated by LS-DYNA from these node sets.

The stress intensities, shown in Tables 4.2-45 and 4.2-47 of the SAR, and the design margin for the design and service conditions for both 45.7- and 61.0-cm [18- and 24-in]-diameter storage tubes are listed in Table 4.2-48 of the SAR. Design margin is defined as the ASME stress intensity limit divided by the actual calculated stress, minus one. A net positive design margin is required to demonstrate compliance with the ASME stress intensity limits. The ISF storage tube confinement structure and internals analysis has demonstrated compliance with 10 CFR §72.24(a) and (d); §72.122(b), (c), and (h); and §72.128(a).

5.1.2 Pool and Pool Confinement Facilities

This provision is not applicable to 10 CFR Part 72 dry storage facilities.

5.1.3 Reinforced Concrete Structures

Multiple reinforced concrete structures in the ISF Facility have been classified as important to safety. This section contains a review of Sections 4.2.2, “Installation Layout;” 4.2.3.2.1, “Description of the Storage Vault;” and 4.7.3.1, “Function of Fuel Handling Operations Area,” of

the SAR. The staff reviewed the discussion on reinforced concrete structures important to safety with respect to the applicable regulatory requirements, as discussed next. The ISF Facility CRA load-bearing structures and footings, transfer area structural concrete and confinement boundary, and storage area concrete vault structure are independent structural units constructed of reinforced concrete, designed in accordance with ACI 349-97 (American Concrete Institute, 1998).

5.1.3.1 Description of Reinforced Concrete Structures

Cask Receipt Area

The CRA, shown in Figures 4.2-1 and 4.2-9 of the SAR, is a steel-framed building anchored to a concrete foundation. The concrete slab that supports the trolley rails, the concrete footings and foundation that support the cask receipt crane, and the footings and foundations that support the primary structural steel of the CRA are considered important to safety structures. The primary structural steel providing a load path for the cask receipt crane (center tower structure) is considered important to safety. The SAR provides a design description of the ISF Facility CRA reinforced concrete structures in sufficient detail to support a detailed review and evaluation in accordance with 10 CFR §72.24(a) and §72.24(b). Descriptions of the ISF Facility CRA reinforced concrete structures and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). These CRA reinforced concrete structures also incorporate the capability for retrieving the SNF as required by 10 CFR §72.122(l).

Transfer Area

A discussion of the confinement boundary for the transfer area is contained in Section 5.1.1 of this SER. As indicated in the SAR, the performance objectives for the FPA beyond those for a confinement boundary include:

- Prevent damage to SNF during normal, off-normal, and accident conditions (important to safety function);
- Ensure SNF remains in a subcritical configuration during normal, off-normal, and accident conditions (important to safety function);
- Provide the capability to maintain SNF temperatures within allowable material limits (important to safety function);
- Provide a structural load path and foundation for the rails of the FHM (important to safety function);
- Provide structural support and foundation for the bench vessels that contain SNF (important to safety function);
- Prevent missiles generated by the design basis tornado from impacting SNF being handled in the FPA (important to safety function);
- Prevent damage to SNF during the DBE (important to safety function);
- Prevent damage to the SNF by maintaining the structural integrity of the confinement barrier during the design basis flood (important to safety function);
- Provide visual capability through shielded windows and closed-circuit television (CCTV) to allow observation, inspection, and documentation of SNF packaging operations;

- Prevent damage to SNF by mitigating the effects of a fire at the ISF Facility;
- Provide temporary storage capability for SNF arriving at the ISF Facility before packaging into ISF canisters;
- Provide shielding to workers in the operating gallery and surrounding office and maintenance areas as a result of direct radiation from the SNF handled in the FPA;
- Provide a physical personnel barrier to restrict unauthorized or inadvertent entry to prevent worker exposure to very high radiation dose rates;
- Provide an area to perform remote SNF handling operations; and
- Provide a shielded area to permit maintenance and repair activities on the FHM

The FPA is constructed of thick reinforced concrete walls, floor, and ceiling. As identified in the SAR, the design of the reinforced concrete structures is based on results of the analyses that identify the section properties and reinforcements required to meet the design basis loads. The SAR provides a design description of the ISF Facility FPA reinforced concrete structures in sufficient detail to support a detailed review and evaluation in accordance with 10 CFR §72.24(a) and §72.24(b). Descriptions of the ISF Facility FPA reinforced concrete structures and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). These FPA reinforced concrete structures also incorporate the capability for retrieving SNF as required by 10 CFR §72.122(l).

Storage Area

The storage vault is a reinforced concrete structure between the CRA and the transfer area as shown in Figures 4.2-1 and 4.2-9 of the SAR. Section 4.2.3.2.1, “Description of the Storage Vault,” of the SAR states that the storage vault system provides storage for 45.7- and 61.0-cm [18- and 24-in]-diameter ISF canisters placed in storage tubes. Two separate storage vault modules are in the vault structure, designated Vault 1 and Vault 2. Vault 1 is positioned west of Vault 2. The vault structural elements are designed of reinforced concrete to provide radiation shielding; structural and seismic stability without loss of function; and tornado protection for the stored SNF.

Although the adjacent Transfer Tunnel is structurally part of the vault structure, it is not considered a functional part of the vault storage system. The storage vault modules are enclosed over their top surfaces by the storage area building, which provides a weatherproof enclosure for canister transfer operations using the CHM.

The storage area building, described in Section 4.7.3.1.5, “Storage Area Building,” and shown in Figures 4.2-9 and 4.3-8 of the SAR, encloses the storage vaults and CHM to provide protection from the environment. The primary structural steel of the storage area building is supported by the reinforced concrete walls of the storage vault. The storage vault codes and standards, materials of construction, fabrication, and quality assurance features are provided in Section 4.2.1.1 of the SAR, including the steel-framed building over the storage vaults. The storage area building is not an important to safety structure; however, the primary structural members of the building have been designed for applicable seismic and tornadic loads.

The spacing of the storage tube array is determined by the structural requirements of the charge face structure. The ligament between adjacent storage tubes provides the beam section properties needed for the charge face structure to span the vault. The charge face and

the support stool provide the upper and lower positioning for the storage tube creating a fixed array, which is used in the thermal, shielding, and criticality analyses.

The vertical loads from the storage tubes are transmitted through the base of the storage tube to support stools bolted to the vault floor slab. Storage tube vertical loads include the dead weight of the storage tube and canister and the dynamic loads resulting from canister handling and seismic effects. The storage tubes do not apply any vertical loads to the charge face structure. The lateral loads from the storage tubes are transmitted at the top end through the charge face encast into the charge face structure and at the bottom end through the support stool into the vault floor slab. Storage tube lateral loads are primarily a result of seismic events. The charge face structure transmits the storage tube lateral loads to the vault walls and from there into the vault foundation.

The vault foundation slab is designed to support the load of the vault modules, including structural weight, facility operations, and off-normal and accident conditions. The foundation slab under the vault modules and the external and internal dividing walls are nominally 0.91 m [3 ft] thick. The charge face structure is 0.76 m [2.5 ft] thick. A parapet wall runs above the north and south edges of the vault to form the runway beam structure for the CHM and a foundation for the structural steel of the storage area building.

The SAR provides a design description of the ISF Facility storage area reinforced concrete structures in sufficient detail to support a comprehensive review and evaluation in accordance with 10 CFR §72.24(a) and (b). Description of the ISF Facility storage reinforced concrete and associated operations procedures includes consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). The storage vault surfaces exposed to the environment will be coated and sealed to prevent cracking and spalling that could occur as a result of thermal contraction and the large number of freeze-thaw cycles expected for the site (Foster Wheeler Environmental Corporation, 2004). The design of the storage area reinforced concrete structures provides for access to all locations and allows for access to the storage casks in the event of emergencies. No barriers built into the ISF Facility would prevent access to any locations. This design allows for emergency response capability, as required in 10 CFR §72.122(g). This reinforced concrete storage area structure also incorporates the capability for retrieving the SNF canisters. Consequently, the SNF can be retrieved from the storage area in accordance with 10 CFR §72.122(l).

5.1.3.2 Design Criteria for Reinforced Concrete Structures

Design criteria for the reinforced concrete structures have been shown to be representative of the site in Chapter 4 of this SER.

Cask Receipt Area

The design criteria for the CRA are provided in Section 4.7.3.3.1, “Cask Receipt Area,” of the SAR. The concrete slab that supports the trolley rails, the concrete footings and foundation that support the cask receipt crane, and the footings and foundations that support the primary structural steel of the CRA are designed to the following principal codes and standards:

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—

Dry Type;

- ACI 349, Code Requirements for Nuclear Related Concrete Structures (for structures, systems, and components important to safety) [as modified by NUREG–1567, paragraph 5.4.3.2, when using ACI 318 (American Concrete Institute, 1999) for construction];
- ACI 318 for concrete structures not important to safety; and
- ASCE 7 (American Society of Civil Engineers, 1999), Minimum Design Loads for Buildings and Other Structures.

The design of the remaining concrete structures of the CRA complies with the following principal codes and standards:

- Uniform Building Code (partially modified by U.S. Department of Energy–Idaho Operations Office Architectural/Engineering Standard for snow loads);
- ASCE 7, Minimum Design Loads for Buildings and Other Structures; and
- ACI 318, Concrete Requirements for Reinforced Concrete Structures

The design bases for the CRA reinforced concrete structures are in compliance with the general design criteria of 10 CFR Part 72, Subpart F. This conclusion also is supported by the structural analysis described in Section 5.1.1.4 of this SER. The CRA reinforced concrete structures are designed in accordance with ultimate strength design methods specified in ACI 349-97 (American Concrete Institute, 1998). The design criteria for the CRA reinforced concrete structures establish the minimum design, fabrication, construction, testing, maintenance, and performance requirements for reinforced concrete structures. Additionally, the design criteria of the CRA reinforced concrete structures address site characteristics and environmental conditions for normal operations and postulated off-normal and accident events. The staff concludes that the CRA reinforced concrete structure design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c) and §72.120(a).

<u>Transfer Area</u>

The design criteria for the transfer area are provided in Section 4.7.3.3.2, "Transfer Area," of the SAR. Details of the design criteria for the transfer area have been discussed in Section 5.1.1.2 of this SER.

<u>Storage Area</u>

The design criteria for the storage area are provided in Section 4.7.3.3.3, "Storage Area," of the SAR. The reinforced concrete structures of the ISF Facility storage area are designed to the following principal codes and standards:

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—Dry Type;
- ACI 349, Code Requirements for Nuclear Related Concrete Structures (for structures, systems, and components important to safety) [as modified by NUREG–1567, paragraph 5.4.3.2, when using ACI 318 (American Concrete Institute, 1999) for construction];
- ACI 318 for concrete structures not important to safety; and

- ASCE 7 (American Society of Civil Engineers (1999), Minimum Design Loads for Buildings and Other Structures.

The design of the structural steel of the storage area building complies with the following principal codes and standards:

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—Dry Type, Sections 5 and 6;
- AISC Manual of Steel Construction, 9th Edition;
- ASCE 7, Minimum Design Loads for Buildings and Other Structures;
- Uniform Building Code (partially modified by U.S. Department of Energy–Idaho Operations Office Architectural/Engineering Standard for snow loads);
- AWS D1.1, Structural Welding Code; and
- Steel Deck Institute, Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Deck Floor Systems with Electrical Distribution.

The conclusions drawn in this section on the storage area reinforced concrete structures design criteria are based on the evaluation findings made in Section 4.1.3 of this SER. The design bases for the storage area reinforced concrete structures given by the applicant are in compliance with the general design criteria of 10 CFR Part 72, Subpart F. The storage area reinforced concrete structures are designed in accordance with ultimate strength design methods specified in ACI 349-97 (American Concrete Institute, 1998). The staff concludes that the storage area reinforced concrete structure design criteria and relevant codes and standards have been identified in accordance with 10 CFR §72.24(c) and §72.120(a).

5.1.3.3 Material Properties for Reinforced Concrete Structures

Cask Receipt Area

The staff reviewed the materials of construction of the CRA reinforced concrete. Material selection is based on concrete with a compressive strength of 27.6 MPa [4,000 psi] following Chapter 5 of ACI 349-97. The reinforcing steel is specified to have a minimum yield strength of 414 MPa [60,000 psi] following Chapter 3 of ACI 349-97 and ASTM standards (American Society for Testing and Materials, 2000). Materials of construction for reinforced concrete structures are based on the following codes and standards:

- Cement: ASTM C150, Specification for Portland Cement;
- Aggregate: ASTM C33, Specification for Concrete Aggregate;
- Reinforcement Steel: ASTM A615, Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement, and ASTM A706 Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement; and
- Embedments: ASTM A36, Standard Specification for Structural Steel Structures.

Fabrication and inspection of the concrete of the CRA are in accordance with

- ACI 349 for concrete structures important to safety (as modified by NUREG–1567, Paragraph 5.4.3.2, when using ACI 318 for construction);

- ACI 318 for concrete structures important to safety (as stated in NUREG–1567, Paragraph 5.4.3.3, when using ACI 318 for construction); and
- ACI 318 for concrete structures not important to safety.

Based on the review of information presented in the SAR, the staff concludes that materials to be used to construct the reinforced concrete structures in the CRA have been described adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Transfer Area

The staff reviewed the materials of construction of the ISF Facility transfer area reinforced concrete structures. The material properties for the transfer area are provided in Section 4.7.3.3.2, "Transfer Area," of the SAR. Material selection is based on concrete with a compressive strength of 27.6 MPa [4,000 psi] following Chapter 5 of ACI 349-97 (American Concrete Institute, 1998). The reinforcing steel is specified to have a minimum yield strength of 414 MPa [60,000 psi] following Chapter 3 of ACI 349-97 and ASTM standards (American Society for Testing and Materials, 2000). Details of the material properties for the transfer area are discussed in Section 5.1.1.3 of this SER.

Storage Area

The staff reviewed the materials of construction of the ISF Facility storage area reinforced concrete. Material selection is based on concrete with a compressive strength of 27.6 MPa [4,000 psi] following Chapter 5 of ACI 349-97. The reinforcing steel is specified to have a minimum yield strength of 414 MPa [60,000 psi] following Chapter 3 of ACI 349-97 and ASTM standards (American Society for Testing and Materials, 2000).

Materials of construction for reinforced concrete structures are based on the same codes and standards as the CRA and the same findings are appropriate. Based on review of the information presented in the SAR, the staff concludes that materials to be used to construct the reinforced concrete structures in the ISF Facility storage area have been described adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

5.1.3.4 Structural Analysis for Reinforced Concrete Structures

Cask Receipt Area

The staff reviewed Section 4.7.3.3.1, "Cask Receipt Area," of the SAR for a discussion of the design of the CRA. This section of the SAR is a summary of the structural evaluations performed in numerous calculations. The structural analysis of the CRA is provided in the following calculation packages as part of the responses to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0152, Cask Receipt Area Steel Design; and
- ISF–FW–CALC–0344, Cask Receipt Area Foundation Design and Analysis.

The CRA consists of a structural steel tower, which supports the cask receipt crane, and a steel framed building. The four steel tower columns are supported by a 1.22-m- [4-ft]-thick mat foundation that also supports the cask and canister trolley rails. The rest of the CRA building is supported by a spread footing isolated from the mat foundation. The CRA was evaluated and designed to include consideration of tornado, earthquake, fire, explosion, flood, lightning, shielding, temperature effects, SNF retrieval, and decontamination.

The 1.22-m- [4-ft]-thick mat foundation supporting the cask receipt crane and the trolley rails was analyzed in a separate finite element calculation using the computer program SAP2000 (Figure 4.7-39 of the SAR) (Computers and Structures Inc., 2000). The mat was modeled as a mesh of shell elements. The soil reaction to the mat was modeled using springs with the spring constants based on the modulus of subgrade reaction for the soil. Enveloped tower column reactions (forces and moments) from the STAAD-Pro (Research Engineers International, 2001) finite element analysis of the CRA and rail loads from analyses of the cask and canister trolleys were used as input for the design of the mat foundation. The forces and moments from the finite element analysis were used to size the thickness and the reinforcement of the mat foundation. This approach was in accordance with the requirements of ACI 349-97 (American Concrete Institute, 1998). The capacity-to-demand ratios for the mat for flexure and shear forces are shown in Table 4.7-10 of the SAR.

Because there are no lateral soil loads on the CRA, overturning and sliding are considered only for tornado wind pressure loads and earthquake combinations. Earthquake loads were determined using a static analysis method. Inertial forces resulting from the steel structure were calculated using the total mass of the steel structure and applying the floor acceleration values at the crane rail level of the CRA (close to the center of mass of the steel structure). The inertial forces resulting from the mat foundation were calculated using the floor accelerations at the base of the CRA (input spectra). The in-structure floor accelerations were taken from the soil-structure interaction analysis. The minimum capacity-to-demand ratio for sliding in the east-west direction was 1.13, based on seismic loading. The minimum ratio of 1.11 for overturning in the east-west direction was based on the tornado wind loads. In the north-south direction, the seismic load controlled sliding had a capacity-to-demand ratio of 1.15. The tornado loads controlled overturning in the north-south direction had a ratio of 1.70. These results are documented in Table 4.7-11 of the SAR. These ratios are greater than the minimum allowable ratio of 1.1.

The CRA reinforced concrete structures, as described in the SAR, are designed to meet the requirements of ACI 349-97 (American Concrete Institute, 1998). The staff accepts the strength design method presented in ACI 349-97 for concrete structures important to safety. The reinforced concrete structures important to safety were analyzed for normal, off-normal, and accident loading conditions. These analyses were performed to ensure the reinforced concrete structures important to safety would be able to perform the intended safety functions during the extreme environmental and natural phenomena as specified in 10 CFR §72.122(b)(1) and (b)(2) and in ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992).

The staff reviewed the SAR and finds the structural analysis procedures have been identified and are in conformance with standard engineering practice, as described in ACI 349-97 (American Concrete Institute, 1998). The relationship between the design criteria, identified in Chapter 3 of the SAR, and the analysis procedures was established in accordance with the

requirements of 10 CFR §72.24(c)(2). The applicable codes and standards used in the analysis of the CRA reinforced concrete structures have also been identified in the SAR, in accordance with the requirements of 10 CFR §72.24(c)(4).

Transfer Area

The staff reviewed Section 4.7.3.3.2, “Transfer Area,” of the SAR for a discussion of the design of the transfer area. The transfer area was evaluated and designed to include consideration of tornado, earthquake, fire, explosion, flood, lightning, shielding, temperature effects, SNF retrieval, and decontamination. Details of the material properties for the transfer area are discussed in Section 5.1.1.4 of this SER.

Storage Area

The staff reviewed Section 4.7.3.3.3, “Storage Area,” of the SAR for a discussion of the design of the storage area. This section of the SAR is a summary of the structural evaluations performed in numerous calculations. The structural analysis of the storage area is provided in the following calculation packages as part of the responses to the staff’s request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0332, Storage Area Finite Element Structural Analysis Thermal Load Cases ;
- ISF–FW–CALC–0335, Concrete Temperatures for Thermal Stress Analysis—Storage Area;
- ISF–FW–CALC–0336, Storage Area—Foundation Design and Analysis;
- ISF–FW–CALC–0337, Storage Area—Design of Concrete Walls and Columns;
- ISF–FW–CALC–0338, Storage Area—Design of Beams and Slabs; and
- ISF–FW–CALC–0339, Storage Area Soil-Structure Interaction and Fixed—Base Analysis Comparison.

The storage area comprises the concrete storage vault structure, the adjoining south section of the Transfer Tunnel, and a steel-framed structure that covers the storage vaults and provides weather protection for the CHM. The reinforced concrete storage vaults and Transfer Tunnel structure are classified as important to safety. The steel building is classified not important to safety. The storage area was evaluated and designed to include consideration of tornado, earthquake, fire, explosion, flood, lightning, shielding, temperature effects, SNF retrieval, and decontamination. The load cases and combinations listed in Table 4.7-7 of the SAR were included in the structural analysis of the storage area.

The structural analysis methodology included static and response spectra methods. The multipurpose finite element analysis program, SAP2000 (Computers and Structures Inc., 2000), was used to model and analyze the storage area. The steel structure not important to safety that covers the storage area was included in the finite element model of the storage area specifically for its effect on the concrete structure. The mathematical model developed for the storage area structures was generated in accordance with requirements in ASCE 4-86 (American Society of Civil Engineers, 1986) and Regulatory Guide 1.92 (U.S. Nuclear Regulatory Commission, 1976). The reinforced concrete walls, slabs, and foundation mats were simulated by the SAP2000 shell element. Other linear elements use the SAP2000 frame element. This element represents beams and truss-type members in the model, with

either prismatic or nonprismatic sections. Nodes were located to capture true geometric properties and configurations, attain regular shell mesh shapes and aspect ratios, and locate dominant point masses.

The SAP2000 program includes a structural section library for rolled steel sections contained in the AISC manual (American Institute of Steel Construction, 1989). Stiffness of reinforced concrete elements was modeled using concrete material properties and the gross thickness of the element. Structural analysis results are reported as nodal, element forces and moments, or both, which were then used for member structural design. The storage area model contains rigid elements and nodal constraints to simulate eccentricities, member offsets at multimember connections, and nodal coupling. The CHM was explicitly modeled with the building structure. The model of the CHM included main girders, vertical members, appropriate member releases, and lumped masses to capture its static and dynamic characteristics. The CHM crane girders and turret were positioned to produce the most critical loads in the storage area walls. Significant masses of other equipment were applied at designated locations and positioned to capture the most critical dynamic effects on the supporting structure.

The storage area is located between the transfer area and CRA. These structures are isolated from one another by a seismic gap that was sized based on the relative seismic deflections calculated from the soil-structure interaction analysis. The effects of the structure-soil-structure interaction were captured into the response spectra generated by the soil-structure interaction analysis.

Static structural analysis refers to the methodology used to analyze the structure for static load cases. The static load cases are combined linearly with the multisolution response spectra seismic case. A separate finite element analysis was performed to evaluate thermal response of the storage area because different boundary conditions were required. Thermal effects caused by changes in material temperature from the reference temperature (assumed stress free) to a final steady-state temperature were captured in this analysis. The effect of the temperature gradient across the shell thickness also was included in the thermal analysis. A detailed assessment of the thermal analysis is given in Chapter 6 of this SER.

The time history soil-structure interaction analysis described in Section 3.2.3.1.8 of the SAR was performed to investigate soil-structure interaction effects and to develop in-structure response spectra for the storage area. Modal response characteristics were evaluated, and the fundamental frequencies in three global directions were noted. Structural analyses of the combined steel and reinforced concrete structures with seismic loads were performed using the response spectra method. The method of combining modal responses and spatial components is in accordance with Regulatory Guide 1.92 (U.S. Nuclear Regulatory Commission, 1976).

Because many load cases and combinations were defined in the storage area structural analyses, enveloping load cases were formulated to evaluate the structural demands on the reinforced concrete components. This enveloping method provides a simplified method to evaluate the component based on maximum design conditions. Preliminary member sizing was based on the enveloping load case defined next. Portions of the structure may be evaluated more rigorously by evaluating individual load cases.

Walls and slabs were designed for axial, flexural, and shear forces in the sections. The input forces and moments for each wall or slab were taken from the contour plots of the shell element

forces and moments from the enveloped load cases. The reinforcement used to determine the concrete capacity was calculated based on the requirements of ACI 349-97 (American Concrete Institute, 1998). The reinforced concrete walls were designed based on demands resulting from axial, flexure, and shear forces for each main section of wall. The thickness of the walls is based on the radiological shielding requirements. The contour plots of enveloped forces and moments caused by static and seismic loads and thermal loads were used to determine the design forces and moments. The design of the main horizontal and vertical reinforcement in the wall sections is controlled by the combined flexure and axial loads. The actual design of the concrete wall sections was performed in accordance with the requirements of ACI 349-97. Table 4.7-22 of the SAR provides a summary of the capacity-to-demand ratios for various wall sections in the storage area (based on ACI 349-97 requirements).

Enveloping load combinations were formulated based on the static and dynamic load combinations and the thermal load combinations. The combined response from these enveloping load combinations was used to evaluate the structural demands on the reinforced concrete foundation. The mat foundation for the storage area was analyzed in a separate finite element calculation using the computer program SAP2000. The detailed finite element model of the storage area described in the preceding paragraphs was used, and the boundary conditions were modified by supporting the base of the structure on soil springs. Static accelerations were used to represent the seismic loads. The maximum building accelerations at the center of gravity of the structure were taken from the response spectra analysis and applied to the model with soil springs. The foundation portion of the finite element model is shown in Figure 4.7-70 of the SAR. The design forces and moments used for flexure and shear design of the mat were taken from contour plots of the enveloped forces and moments. Capacity-to-demand ratios for the mat were calculated in accordance with the requirements of ACI 349-97. The capacity of the mat for bending moments and out-of-plane shear is shown in Table 4.7-10 of the SAR. The minimum capacity-to-demand ratio for sliding in the east-west direction was 1.23, based on seismic loading. The minimum ratio of 3.4 for overturning in the east-west direction also was based on the seismic loads. In the north-south direction, the seismic load controlled sliding and overturning and had capacity-to-demand ratios of 1.56 and 4.3, respectively. These results are shown in Table 4.7-21 of the SAR. These ratios are greater than the minimum allowed ratio of 1.1.

The reinforced concrete slabs and beams were designed based on demands from axial, flexure, and shear forces for each main section. The thickness of the slabs is based on radiological shielding requirements. Contour plots of enveloped forces and moments caused by static, seismic, and thermal loads were used to determine the design forces and moments. The design of the concrete slab and beam sections was performed in accordance with the requirements of ACI 349-97. Table 4.7-24 of the SAR provides a summary of the capacity to demand ratios for various slabs and beams in the storage area (based on ACI 349 requirements).

The relative displacements caused by seismic loads were calculated from the soil-structure interaction analysis and are presented in Table 4.7-19 of the SAR. The maximum relative displacement is less than 5.1 mm [0.20 in]. The relative vertical displacement between the charge face and the vault base is of interest to ensure control of the gaps between the storage tube and the charge face penetration liners. The maximum vertical relative displacement is less than 2.5 mm [0.10 in].

The storage area reinforced concrete structures described in the SAR are designed to meet the requirements of ACI 349-97 (American Concrete Institute, 1998). The staff accepts the strength design method presented in the ACI 349-97 for concrete structures important to safety. The reinforced concrete structures important to safety were analyzed for normal, off-normal, and accident loading conditions. These analyses were performed to ensure the reinforced concrete structures important to safety would be able to perform their intended safety functions during extreme environmental and natural phenomena as specified in 10 CFR §72.122(b)(1) and (b)(2), and in ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992).

The staff reviewed the SAR and finds that the structural analysis procedures have been identified and are in conformance with standard engineering practice, as described in ACI 349-97. The relationship between the design criteria, identified in Chapter 3 of the SAR, and the analysis procedures was established in accordance with the requirements of 10 CFR §72.24(c)(2). The applicable codes and standards used in the analysis of the storage area reinforced concrete structures also have been identified in the SAR in accordance with the requirements of 10 CFR §72.24(c)(4).

5.1.4 Other Structures, Systems, and Components Important to Safety

This section contains a review of Sections 4.3, “Auxiliary Systems,” and 4.7.3.2, “Components for Fuel Handling Operations,” of the SAR. The staff reviewed the discussion of other structures, systems, and components important to safety with respect to the applicable regulatory requirements.

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

The following structures, systems, and components were identified in the SAR as other structures, systems, and components important to safety. The staff reviewed the descriptions of these structures, systems, and components important to safety with respect to the regulatory requirements of 10 CFR §72.24(b) and §72.122(f) and (g).

Seismic Switch

A seismic switch, consisting of seismic sensors in conjunction with redundant load interrupter switches installed in the 13.8-kV feed to the stepdown transformer, will automatically deenergize the normal and standby power supply and initiate a signal to prevent the standby diesel generator from starting. The sensors are triaxial accelerometers to detect the ground response. There are three triaxial sensors, and two-out-of-three voting logic is implemented to reduce the likelihood of spurious trips. The seismic switch is powered by a dedicated uninterruptable power supply (UPS). The switches remain open until manually reset in accordance with facility operating procedures.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of the seismic switch. The seismic switch has been sufficiently described in accordance with 10 CFR §72.24(b).

Electrical Interlocks

The ISF Facility interlock system coordinates control signals between systems and components. Each status or alarm signal produced by one structure, system, or component and required by the operating logic of a second structure, system, or component is defined and managed by the facility interlock system. It is a distributed system without central equipment or a primary location. Protective interlocks are designed to prevent potentially hazardous operations or conditions. Operational interlocks, along with operator demand or confirmation, determine equipment operation. The combination of operator action (demand or confirmation) and operational interlocks ensures that any active processes (such as fuel movement) at the ISF Facility are conducted by facility staff, with fail-safe design features to provide added protection.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of electrical interlocks. The electrical interlocks have been sufficiently described in accordance with 10 CFR §72.24(b).

Cask Receipt Crane and Associated Lifting Fixtures

The cask receipt crane is a fixed single-failure-proof hoist mounted on a large structural steel tower inside the CRA. Figures 4.7-1 and 4.2-9 of the SAR show the hoist and steel tower. The cask receipt crane is used to lift the transfer cask from the transporter onto the cask trolley. The cask receipt crane has a rated capacity of 141 tonne [155 ton] and a working capacity of 136 tonne [150 ton]. A loaded transfer cask weighs approximately 32 tonne [35 ton]. The lift links are attached to the transfer cask lifting trunnions and are used to raise and lower the transfer cask in a single-failure-proof mode.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the cask receipt crane and associated lifting devices allows control of loads in event of emergency. The cask receipt crane and associated lifting devices have been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Cask Receipt Area

The CRA, shown in Figures 4.2-1 and 4.2-9 of the SAR, is a steel-framed building anchored to a concrete foundation. The CRA includes the structural steel tower that supports the cask receipt crane. The SAR provides a design description of the CRA structural steel in sufficient detail to support a comprehensive review and evaluation in accordance with 10 CFR §72.24(a) and §72.24(b). Descriptions of the CRA structural steel and associated operations procedures include consideration of inspection, maintenance, and testing as required in 10 CFR §72.122(f). Design of the ISF Facility allows access to all locations and regions in event of emergencies. The design provides access in accordance with the requirements of 10 CFR §72.122(g).

Fuel Packaging Area

This section describes various components important to safety located in the FPA. The FPA shield doors, shown in Figures 4.7-18 and 4.7-19 of the SAR, consist of one vertical door and one horizontal sliding door that will be opened to allow the FHM to pass through and then closed to enable maintenance of the FHM. The FPA shield doors are constructed from carbon-steel plates. The vertical door is suspended from two screw jacks. Rollers and guides are mounted on the door and provide support to keep the door in place during and following a seismic event. The horizontal door runs on wheel modules on a rail mounted to the wall inside the FHM maintenance area. Attached to the base of the door is a seismic restraint that acts to keep the door on its rail during and following a seismic event. The FPA shield doors are classified as not important to safety; however, the FPA shield doors are seismically designed to withstand the DBE when closed.

The personnel shielded access door, shown in Figure 4.7-20 of the SAR, is constructed from carbon-steel plate mounted on two hinge assemblies to a steel door frame and a single latch mechanism on the opposite side. The personnel shielded access door is approximately 1.22 m [4 ft] wide by 2.14 m [7 ft] high. The personnel shielded access door is classified important to safety, because it forms part of the FPA confinement barrier. This door is designed to withstand tornado and seismic loads and to minimize leakage.

The FPA bench vessels are flanged tube assemblies that provide stability and support to the U.S. Department of Energy canisters and ISF baskets while individual SNF elements are removed or loaded within the FPA. There are eight main bench vessels in the FPA. Five are used to support packaging and processing of the various SNF types, and the other three bench vessels are used to provide temporary storage for empty SNF cans and canisters to support solid waste processing activities. Most of the bench vessels are constructed from stainless steel or coated carbon-steel pipe with flanges welded to the top and a steel pipe support stool welded to the bottom. The bench vessels are sized with sufficient clearance to ensure smooth loading and unloading of the various canisters, baskets, adapters, and liner buckets. The bench vessels supporting and providing temporary storage of SNF and are classified important to safety.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the FPA allows control of loads in the event of emergencies. The FPA has been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Transfer Tunnel

The Transfer Tunnel, shown in Figures 4.2-1 and 4.2-9 of the SAR, provides a shielded and protected route for the cask trolley to travel safely between the CRA and the FPA and the canister trolley to travel among the FPA, the CCA, and the storage area. The Transfer Tunnel is structurally part of two separate areas. The south Transfer Tunnel section is integral with the storage area vaults and was designed and analyzed as part of that structure. The north Transfer Tunnel section is integral with the transfer area structure and was designed and

analyzed as part of that structure. A seismic isolation joint between these two structures allows differential movement during the DBE.

The Transfer Tunnel is constructed primarily of reinforced concrete. Rails attached to the floor of the tunnel provide the load path for both the cask and canister trolley. Access ports in the ceiling of the Transfer Tunnel allow access to the second floor of the storage area building, FPA, and CCA. These ports have removable port plugs, which are normally installed unless transfer operations or ISF canister closure activities are occurring. The cask port plug weighs approximately 3,789 kg [8,354 lb] and is 1.57 m [62 in] at its largest diameter. The cask port plug is made from a fabricated steel exterior shell filled with concrete and has stepped sides to provide shielding and positive positioning inside the port opening. The canister port plug weighs approximately 1,206 kg [2,568 lb] and is nominally 0.98 m [38.5 in] at its widest diameter. The canister port plug is made of steel and has stepped sides to provide shielding and positive positioning inside the port opening. The CCA port cover is made of carbon steel plate, has a diameter of approximately 1.37 m [54 in], and weighs approximately 871 kg [1,920 lb]. The storage area load and unload port has a thick steel cover plate that protects the port plug from tornado missiles and damage that could occur during routine maintenance in this area. The cover plate weighs approximately 465 kg [1,025 lb].

The Transfer Tunnel is separated from the CRA by a steel outer door that provides tornado protection to the cask and canister trolleys during SNF transfer operations inside the Transfer Tunnel. A second door is installed at the north end of the cask decontamination zone of the Transfer Tunnel.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the Transfer Tunnel allows control of loads in event of emergencies. The Transfer Tunnel has been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Canister Closure Area

The CCA, shown in Figures 4.7-15 and 4.7-16 of the SAR, provides a controlled area to perform canister closure activities, which include welding, purging, vacuum drying, inerting, inspecting, and testing. The CCA is a reinforced concrete room approximately 6.71 m [22 ft] wide by 12.2 m [40 ft] long and 8.22 m [27 ft] high, located immediately north of the FPA. The CCA building is structurally part of the FPA and is located within the transfer area of the ISF Facility. Adjacent to the CCA is an operations office and equipment room for operators to monitor canister closure operations. The vacuum-drying and helium-fill equipment is located there. A large observation window between the operations office and the CCA allows operators to view the automatic welding, vacuum-drying, helium-fill, and leak detection sequences while remaining outside the immediate CCA working area. Use of remotely operated equipment reduces the dose burden to the operators.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operation of structures, systems, and components important to safety. The CCA has been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Confinement Boundary Through-Wall Penetrations

All penetrations that are part of the confinement boundary will be designed in accordance with the same codes and standards used for the confinement boundary.

Cask and Canister Trolleys and Cask Adapter

The cask trolley, shown in Figure 4.7-2 of the SAR, is a steel-fabricated structure mounted on four rail wheels. The cask trolley is used to move the transfer cask containing SNF from the CRA to the FPA. The cask trolley, cask adapter, and inflatable seal are classified as important to safety.

The cask trolley is single-failure-proof in accordance with NUREG–0554 (U.S. Nuclear Regulatory Commission, 1979). The maximum weight the cask trolley will transport is a transfer cask, cask adapter, and cask lid lifting device, for a total design load of approximately 32 tonne [35 ton]. The cask trolley is constructed of a carbon steel-fabricated framework mounted on four wheels to form a base platform. The transfer cask is supported in an elevated position on the cask trolley to present it at the correct height at the cask port beneath the FPA. One side of the framework has a vertical opening to allow side loading of the cask onto the cask trolley. This feature minimizes the height the transfer cask must be raised to position it on the cask trolley. After the transfer cask is placed onto the trolley, a restraint device is used to close this opening and ensure that the cask remains in an upright position while the cask adapter is being installed. A cask adapter, made from a stainless steel-fabricated ring, is installed over the top of the transfer cask. The cask adapter is installed inside the CRA after the transfer cask is situated inside the cask trolley. The cask adapter rests on the upper trunnions of the transfer cask and is positioned on the outside of the cask body and lid to allow the lid to be removed inside the Transfer Tunnel.

The canister trolley, shown in Figure 4.7-4 of the SAR, is used to move loaded ISF canisters from the FPA to the CCA for closure lid welding, purging, and inerting, and then from the CCA to the storage area load and unload port. The canister trolley (canister trolley and the canister cask assemblies) provides capabilities for lifting, handling, and transferring SNF. Therefore, the canister trolley is classified as important to safety.

The canister trolley includes the trolley frame, wheel base platform, wheels, seismic restraints, actuated locking pin system, and canister jacking system. The canister cask is attached permanently to the canister trolley and is not removed during SNF handling operations. The canister trolley is fabricated from a carbon steel framework mounted on four wheels to form a base platform. Mounted on the base platform is a carbon steel-fabricated framework to support a jacking system and guide for the canister cask. A cask-jacking system, comprising multiple inverted translating screw actuators, is mounted on the canister trolley framework.

Trolley wheels are protected from jamming by track debris deflector plates mounted close to the rail in front of and behind each wheel module. The trolley design prevents the trolley from being derailed during normal operations, a seismic event, or an impact event. In event of a wheel or axle failure, the trolley fall is limited to 2.54 cm [1 in]. Jacking points allow replacement of a wheel or axle module while a loaded trolley is within the Transfer Tunnel. The trolley uses a locking pin that extends from the base platform and fits into an engineered cavity in the floor. This feature locks the trolley into position before unloading and ensures the trolley will remain

locked in position if a seismic event should occur. To move along the Transfer Tunnel, the trolley uses an onboard electric motor gear unit to drive a pair of wheels. The motor gear unit has an electromagnetic brake and clutch. With a loss of electrical power, the brake is fail safe to stop canister trolley motion.

The description of the trolleys includes consideration of inspection, maintenance, and testing in accordance with CMAA No. 70 (Crane Manufacturers Association of America, 1994), which is the primary document used for fabrication, construction, and testing criteria for the cask and canister trolleys, except where the recommendations of ANSI N14.6 (American National Standards Institute/American Nuclear Society, 1993) and NUREG–0612 (U.S. Nuclear Regulatory Commission, 1980) or other standards are specified, as discussed in Section 5.1.4.3 of this SER. Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the cask and canister trolley allows control of loads in event of emergencies. The cask and canister trolleys have been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Cask and Canister Inflatable Seals, Check Valves, Relief Valves, and Connecting Tubing

When the cask trolley is positioned below the cask port, there is a gap between the cask adapter and the cask port. With the transfer cask in position, an inflatable seal mounted around the underside of the cask port (Figure 4.7-11 of the SAR) is deployed using compressed air. This inflatable seal contacts the machined surface of the cask adapter and seals the interface between the FPA and the Transfer Tunnel. This seal provides a continuous confinement barrier between the FPA and the transfer cask before opening the cask port. This feature also minimizes the disruption to the HVAC system flow balance and the potential for the spread of contamination. After completion of SNF transfer operations from the transfer cask to the FPA, the transfer cask lid is reinstalled, the cask port plug is replaced in the cask port, and the cask port seal is deflated. At this time, the confinement boundary inside the FPA becomes the cask port plug.

When the canister trolley is in position at the canister port below the FPA, the canister cask is jacked up into a recess in the Transfer Tunnel ceiling. A separate inflatable seal (Figure 4.7-12 of the SAR) is inflated using compressed air to close the radial gap between the canister cask and the Transfer Tunnel recess. This seal extends the FPA confinement barrier into the canister cask when the canister port plug is removed. This seal also minimizes the disruption to the HVAC system flow balance and the potential spread of contamination. After SNF transfer operations into the ISF canister are completed, the canister shield plug is installed into the ISF canister and the canister port plug is replaced. At this time, the confinement boundary inside the FPA becomes the canister port plug.

The cask port and canister port seals are inflated by the facility’s compressed air system. Seal deflation is avoided during transfer operations through the use of a pilot valve and check valves. Seal deflation is achieved by actuating a solenoid valve that applies air to the pilot to vent the inflated seal. The solenoid and pilot valve fail-safe position is to prevent seal deflation by blocking the vent path. A relief valve prevents overinflation of the seals, and pressure switches monitor the minimum and maximum inflation pressures with indication in the operating gallery.

The pilot valve, check valves, and relief valve and the associated connecting tubing to the seals are classified as important to safety and are seismically designed.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The inflatable seals and associated hardware have been described sufficiently in accordance with 10 CFR §72.24(b).

<u>Fuel Handling Machine</u>

The FHM, shown in Figure 4.7-3 of the SAR, is a 4,536-kg [10,000-lb] bridge/trolley crane designed to operate in the FPA. It has a single-failure-proof hoist designed in accordance with NUREG–0554 (U.S. Nuclear Regulatory Commission, 1979). The FHM consists of an overhead electric crane with a top running bridge and cross travel trolley. The FHM is mounted on rails that run in the east-west direction through the FPA and into the FHM maintenance area. The FHM is equipped with a hoist unit. A range of lifting devices designed for attachment to the FHM hoist provides capability for the various lifting applications associated with handling the different SNF types, U.S. Department of Energy containers, and ISF baskets in the FPA.

A range of dedicated special lifting devices work in conjunction with the FHM to lift and move various loads inside the FPA. Each special lifting device provides a safe load path between the FHM hook and the item being lifted. No electrical, hydraulic, or pneumatic services are required to operate the special lifting devices. Latching is performed by mechanical means operated by the power manipulator system (PMS) or master/slave manipulator (MSM). The FHM lifting devices are suspended from the FHM hoist hook. Only the required special lifting devices needed for a specific SNF packaging campaign will be in the FPA during that campaign. Lifting devices that provide a load path to support SNF or handle the transfer cask lid are classified as important to safety. Table 4.7-6 of the SAR provides a list of lifting devices important to safety for the FHM including a description of the item lifted. These lifting devices important to safety use a single load path requiring increased stress design factors in accordance with ANSI N14.6, Section 7, "Special Lifting Devices For Critical Loads" (American National Standards Institute/American Nuclear Society, 1993).

The PMS is an electrically powered robotic arm mounted on a telescopic mast, which, in turn, is mounted on the bridge of the FHM. The telescopic mast is a multipart telescopic tube set that can retract to 2.44 m [8 ft] and extend to 6.71 m [22 ft]. The manipulator arm and remotely detachable jaw and associated tools are used to remotely latch and delatch the special lifting devices on the FHM hoist hook. The PMS is fitted with a load cell to prevent the PMS from overloading by tripping an interlock if the design load rating is exceeded. The PMS does not routinely handle SNF and is not designed to be single-failure-proof.

Operational and load-carrying components of the FHM are classified as important to safety. The PMS is classified not important to safety.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the FHM and associated lifting devices

allows control of loads in event of emergencies. The FHM and associated lifting devices have been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

Worktable and Tipping Machine

The worktable, shown in Figure 4.7-14 of the SAR, is a multipurpose table bolted to the FPA workbench incorporating various machines and equipment. The worktable is designed for safe handling and decontamination of empty waste containers (e.g., canisters, cans, buckets) used in the transfer of SNF. The worktable also has the capability to allow recovery from anticipated problems that may occur during SNF processing activities, including the handling and recovery of broken or stuck SNF elements. The primary components of the worktable are as follows:

- The tipping machine, which is used to rotate a fuel can complete with SNF element (Peach Bottom–1) from the vertical position to a horizontal axis position on the worktable;
- The can-cutting machine, which is used to cut off the bottom of the Peach Bottom–1 fuel cans and TRIGA fuel cans;
- The down-ender and rotate machine, which are used in conjunction with the FHM to lower a U.S. Department of Energy canister or Shippingport liner from the vertical position to a horizontal position on the worktable;
- The canister slitting saw, which is mounted on a dovetail slide assembly fixed to the worktable. The traverse of the saw, which will be adjusted by an MSM, will enable the cutting of U.S. Department of Energy canisters or Shippingport liners;
- Sets of rollers, which are fixed to the worktable to support the canister when it is lowered to the down-ender and rotate machine by the FHM. Each set of rollers is mounted on a fabricated bracket to support the canister at the correct height. The fabricated brackets are bolted to the worktable at the correct spacing to support the canister along its length;
- The jacking attachment, which is a screw jack mounted on a bracket, assembled onto the back of the can-cutting machine; and
- The rodding attachment, which assembles to the back of the can-cutting machine as an alternative to the jacking attachment. The rodding attachment is designed to push broken SNF element parts out of the fuel can and into a new container for broken fuel elements.

The worktable and tipping machine are classified as important to safety because they may support SNF. The balance of the worktable attachments are classified not important to safety.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The design allows emergency load-carrying capability. Design of the worktable and tipping machine allows control of loads in event of emergencies. The worktable and tipping machine have been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

HVAC and HVAC Breakaway Joint

The HVAC system is designed to prevent the accidental release of radiological hazards to the environment, to keep personnel exposure to radiological hazards as low as reasonably

achievable (ALARA), to maintain environmental conditions for habitability and reliable equipment operation, and to provide integrated systems that support safe operation of the ISF Facility. The ventilation and off-gas systems at the ISF Facility consist of the following subsystems:

- CRA (Figure 4.3-1 of the SAR);
- Storage area (Figure 4.3-2 of the SAR);
- Transfer area (Figures 4.3-3 and 4.3-4 of the SAR);
- Operations area; and
- Miscellaneous areas

HEPA filters are installed in the supply air system to the FPA, FHM maintenance area, solid waste storage area, and solid waste processing area to prevent the spread of contamination should a flow reversal occur in these areas. Fire dampers and tornado dampers are provided at ductwork penetrations into the FPA and FHM maintenance area.

The HVAC system is not required to operate during or after design basis accidents, including a design basis tornado, or a seismic event. The HVAC system is not required to mitigate a design basis flood and will be manually shut down if a flood occurs. Only portions of the HVAC ductwork and breakaway joints are classified as important to safety. The remainder of the HVAC system is classified as not important to safety. However, the main supply and exhaust fans serving the transfer area must be reliable to ensure SNF handling operations are not affected. Therefore, 100-percent redundant backup fans are provided to allow for periodic maintenance and duty cycling. The effects of loss of filter integrity are minimized through use of local intermediate filters, prefilters in the final HEPA housings, and dual HEPA filtration sections in series in the final HEPA housings.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The HVAC ductwork has been described sufficiently in accordance with 10 CFR §72.24(b).

<u>Breathing Air System (Portion of System That Penetrates FPA Confinement Boundary)</u>

Breathing air provides personnel protection for those areas inside the ISF Facility that have the potential for airborne radioactive contaminants. A high-pressure air compressor, pressure-reducing stations, air dryer, and self-contained breathing apparatus cylinder charging equipment are in the mechanical equipment room. The breathing air system boundaries are limited to the ISF Facility. Only the portion of the breathing air system that penetrates the confinement boundaries is classified as important to safety. The through-wall penetration of the confinement boundary by the breathing air system provides seals to prevent the spread of radioactive contamination.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The breathing air system components have been described sufficiently in accordance with 10CFR §72.24(b).

MSM Through-Wall Tubes and Encasts

An MSM is shown in Figure 4.7-21 of the SAR. The MSMs are mounted adjacent to the through-wall shield windows in the walls of the FPA as shown in Figure 4.2-2 of the SAR. The MSMs extend the dexterous manipulative capabilities of a human operator into a hazardous environment. The master arm is located in the operating gallery and the slave arm inside the FPA. Two through-wall encasts are provided adjacent to each shield window. These positions will not all be occupied by MSMs. Any encast position not occupied by an MSM will have a shield plug installed with the shielding capability of the shield wall. The shield plug can be removed to allow installation of an MSM, should the need arise. Encast liners anchor the through-wall tube during operation of the MSMs and provide seals to prevent the spread of radioactive contamination from the FPA. They also allow the through-wall tubes to be removed easily from the shield walls surrounding the FPA for maintenance and repairs. The MSM through-wall tubes and encasts are classified as important to safety because they form part of the FPA confinement barrier. The balance of the MSM is not important to safety.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The MSM encasts have been described sufficiently in accordance with 10 CFR §72.24(b).

Storage Vault Inlet Vents and Exhaust Louvers

Cooling-air inlet ducts are formed in the north and south walls of the vault nominally at charge face level. The inlet ducts have an offset path to prevent direct radiation streaming from the storage tube assemblies. Mesh screens and a weather canopy over each inlet duct prevent debris, birds, vermin, and such, from entering the vault. Cooling air exits the vault through the charge face structure into the storage area building and is exhausted through louvers placed high in the building walls. Storage vault cooling is passive and self-regulating. The decay heat from the SNF warms the air, thus creating the convection flow to remove decay heat. The fixed inlet vents in the storage vault concrete walls and the exhaust louvers in the storage area are classified as important to safety because they support natural circulation through the storage vault.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The storage vault inlet vents and exhaust louvers have been described sufficiently in accordance with 10 CFR §72.24(b).

Charge Face Cover Plate

The charge face cover plate is a 5.72-cm- [2.25-in]-thick steel disc located in a recess inside the charge face encast. Its top surface is level with the charge face surface, as shown in Figure 4.2-11 of the SAR. An annular gap between the outside diameter of the cover plate and the bore of the charge face is established by four equally spaced pads in the encast to provide a flow passage for the storage tube cooling air. The cover plate is bolted to a shoulder on the encast but is raised off the shoulder by 1.91-cm-[0.75-in]-thick spacers below the cover plate at each cap screw location to maintain the required cooling airflow passageway. Although the

charge face cover plates contribute to overall charge face shielding performance, their primary function is to protect the top of the storage tube from tornado missile impact. Four cap screws hold the charge face cover plate down against the suction pressure resulting from the maximum tornado wind speed. There are two sizes of charge face cover plates, sized for the 45.7- and 61.0-cm [18- and 24-in] storage tube locations.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The charge face cover plates have been described sufficiently in accordance with 10 CFR §72.24(b).

Storage Tube Support Stool

The storage tube support stool assembly is a flat plate with four alignment guides positioned on a pitch circle diameter so the storage tube can fit inside these guides and be laterally located and supported by them, as shown in Figures 4.2-6 and 4.2-13 of the SAR. The support stool is positioned directly below the charge face encast and is anchor-bolted and grouted to the floor of the vaults. Jacking screws on the support stool base plate are provided to set the height and level of each individual support stool before being grouted in position during installation. The support stool transmits the vertical and lateral loads from the base of the storage tube into the vault floor. Storage tube vertical static and dynamic loads are transmitted through the support stool. Vertical loads from the storage tube assemblies are not transmitted to the charge face structure. Seismic events may generate lateral loads from the storage tube assembly. The support stool is designed to withstand these lateral loads from the base of the storage tube and to keep the storage tube in position so that the geometry of the storage array does not change. The charge face encast provides lateral support for the upper end of the storage tube assembly during a seismic event. The lateral support function of the support stool and the charge face encast ensure the storage tube array does not change during a seismic event.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operations of structures, systems, and components important to safety. The storage tube support stools have been described sufficiently in accordance with 10 CFR §72.24(b).

Canister Handling Machine

The CHM, shown in Figures 4.7-5 and 4.7-6 of the SAR, is a shielded rotating turret assembly mounted on a bridge and trolley that runs on rails inside the storage area building. The CHM lifts loaded ISF canister assemblies from the canister trolley and places them in the storage tubes inside the storage vaults. The CHM consists of a bridge and trolley that carries a shielded cask and turret assembly. The CHM moves on rails mounted on a parapet wall that runs in an east-west direction above the charge face floor of the storage area. A single-failure-proof wire rope hoist and grapple system is mounted at the top of the turret assembly to handle the loaded ISF canisters. The total weight of the CHM assembly is approximately 345 tonne [380 ton], and the working capacity of the canister hoist is 4,536 kg [10,000 lb].

The major subassemblies of the CHM include:

- A bridge assembly including girders, cross travel rails, end trucks, long travel drive, wheels, seismic locks, and the power supply collecting system;
- A trolley assembly with structural steel frame, cross travel drive unit, wheels, seismic locks, power supply collecting system, operator control desk, instrumentation and control cubicles, and a turret rotation festoon system used to convey power and control between the trolley and the rotating turret;
- A turret assembly, shown in Figures 4.7-32 and 4.7-33 of the SAR, that incorporates three operational cavities;
- A canister cavity inside the main cask body with a dedicated single-failure-proof canister hoist and grapple for raising and lowering the ISF canisters containing SNF;
- A storage tube plug cavity with a dedicated plug hoist and grapple system for handling tube plugs; and
- A navigation cavity with a CCTV system to position the CHM accurately over the storage tubes or other stations and to view the canister identification numbers.

The shielded cask is designed into the structure of the CHM turret assembly. Gamma shielding consists of steel castings made from carbon steel, while neutron shielding is provided by Jabroc (boron-impregnated densified wood) above and below the turntable fabrication. The completion of the radiation shielding at the interface between the charge face and the nose of the CHM is achieved by lowering the shield skirt when the CHM is connected to a storage tube.

The hoist design is based on a dual rope system with a twin-grooved drum. The hoist drum is driven by a variable speed motor and primary drivetrain external to the hoist structure with a secondary drivetrain connected to the opposite end of the drum. The secondary drivetrain ensures no single failure will result in the loss of the ability to stop and hold a load. The CHM ISF canister grapple, shown in Figure 4.7-34 of the SAR, is a self-centering, eight-jaw grapple, designed to engage, lift, lower, and release the ISF canisters. A pneumatic cylinder controls the jaws operation after the grapple is positioned, and a mechanical lock ensures the jaws cannot be opened when the grapple is carrying a load. The grapple configuration is designed to ensure all jaws can achieve the fully closed position without being constrained by the ISF canister lifting ring. The CHM tube plug hoist and grapple, shown in Figure 4.7-32 of the SAR, are designed to engage and lift, lower, and release tube plugs from the storage tubes.

The CHM is held locked in position during canister raising and lowering operations. This condition avoids the potential for trapping and damaging a canister if uncontrolled movement of the CHM occurs with the canister partially inserted into a storage tube and the CHM. The CHM locking system is designed to withstand seismic forces. To ensure that uncontrolled motion of the CHM does not occur, substantial clamps lock the bridge to the long travel rail system, the trolley to the bridge, and the rotating parts of the turret to the trolley and the nonrotating base casting. The lower ends of the canister and tube plug cavities are automatically closed whenever the upper turret and cask are rotated to the navigation position, thereby completing the shielding requirements. This closure prevents accidental drop of a canister onto the charge face while in transit, and also provides axial gamma shielding.

Components requiring inspection and maintenance are identified, and operational procedures are summarized. Preoperational, startup, and operational tests will be performed to verify the functional operation of structures, systems, and components important to safety. The design

allows emergency load-carrying capability. Design of the CHM and associated lifting devices allows control of loads in event of emergencies. The CHM and associated lifting devices have been described sufficiently in accordance with 10 CFR §72.24(b) and §72.122(f) and (g).

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 (Foster Wheeler Environmental Corporation, 2003a). As identified in the SAR, the other structures, systems, and components important to safety are designed in accordance with the design criteria contained in Chapter 3 of the SAR. This conclusion is supported by the structural analysis performed as described in Section 5.1.3.4 of this SER. Design criteria have been shown in Chapter 4 of this SER to be representative of the site.

<u>Seismic Switch</u>

Operational requirements and site design criteria identified in Chapter 3 of the SAR are sufficient for the commercial grade seismic switch.

<u>Electrical Interlocks</u>

Operational requirements and site design criteria identified in Chapter 3 of the SAR are sufficient for the commercial-grade electrical interlocks.

<u>Cask Receipt Crane and Associated Lifting Fixtures</u>

The design of the cask receipt crane complies with following principal specifications:

- NUREG–0612, Control of Heavy Loads at Nuclear Power Plants;
- NUREG–0554, Single-Failure-Proof Cranes for Nuclear Power Plants;
- CMAA No. 70, Specification for Electrical Overhead Traveling Cranes;
- ANSI N14.6, American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 4,500 kg [10,000 lb] or More ;
- AISC Manual of Steel Construction, 9th Edition;
- National Fire Protection Association (NFPA) 70 (1999), National Electrical Code; and
- AWS D1.1, Structural Welding Code—Steel.

As identified in Section 4.7.3.3.4, “Cask Receipt Crane,” of the SAR, the design of the cask receipt crane considered the following conditions:

- Earthquake—The cask receipt crane is designed for seismic loads using the response spectra method. The cask receipt crane will remain in position and continue to support the maximum design load during and after a seismic event, but may not remain operational. The crane control system is deenergized during and following a seismic event and is fail safe on loss of electrical supply. The cask receipt crane was analyzed loaded and unloaded in the hook-up and hook-down positions.

- Fire or Explosion—The cask receipt crane meets the requirements of NFPA 70, National Electric Code, to minimize the likelihood and effect of any fires that might occur from faulty electrical equipment. Credible fires or explosions in the CRA that may have an adverse effect on the cask receipt crane are discussed in Section 4.3.8 of the SAR.

- Lightning—The cask receipt crane is located inside the CRA building, which is provided with a lightning arrestor system designed in accordance with NFPA 780, Lightning Protection Code (National Fire Protection Association, 1997). The cask receipt crane is also grounded in accordance with electrical design requirements.

- Temperature—Load handling operations are terminated, and the cask receipt crane will remain unloaded at temperatures below 0.0 EC [32 EF] or above 40.6 EC [105 EF].

- Protective Coatings—Protective coatings consist of two finish coats of paint over a single coat of rust-inhibiting metal primer.

The cask receipt crane and associated lift hardware design criteria and relevant codes and standards have been described sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

<u>Cask Receipt Area</u>

The design of the primary CRA structural steel, including the structural steel that supports the cask receipt crane, complies with the following principal codes and standards:

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—Dry Type, Sections 5 and 6;
- AISC Manual of Steel Construction, 9th Edition;
- ASCE 7, Minimum Design Loads for Buildings and Other Structures;
- Uniform Building Code (partially modified by U.S. Department of Energy–Idaho Operations Office Architectural/Engineering Standard for snow loads); and
- AWS D1.1, Structural Welding Code.

The design of the secondary and nonstructural steels complies with the principal codes and standards identified previously, with the exception of ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992).

The conclusions in this section regarding the CRA design criteria are based on the evaluation findings in Section 4.1.3 of this SER. The ISF Facility design criteria and relevant codes and standards have been described sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

<u>Fuel Packaging Area</u>

The design of the FPA complies with the following principal codes and standards:

(i) Concrete Structures (foundations, walls, roof, slabs related to FPA, Transfer Tunnel, and CCA)

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—Dry Type;
- ACI 349, Code Requirements for Nuclear related Concrete Structures (as modified by NUREG-1567 paragraph 5.4.3.2 when using ACI 318 for construction);
- ACI 318, Code Requirements for Reinforced Concrete Structures;
- ANSI A58.1, Minimum Design Loads for Buildings and other Structures; and
- ASCE 7, Minimum Design Loads for Buildings and Other Structures.

(ii) The design of the balance of the concrete complies with the following principal codes and standards:

- Uniform Building Code (partially modified by U.S. Department of Energy–Idaho Operations Office Architectural/Engineering Standard for snow loads);
- ASCE 7, Minimum Design Loads for Buildings and Other Structures; and
- ACI 318, Code Requirements for Reinforced Concrete Structures.

(iii) Primary Steel Structures

- ANSI/ANS 57.9, Design Criteria for an Independent Spent Fuel Storage Installation—Dry Type, Sections 5 and 6;
- AISC Manual of Steel Construction, 9^{th} Edition;
- ASCE 7, Minimum Design Loads for Buildings and Other Structures;
- Uniform Building Code (partially modified by U.S. Department of Energy–Idaho Operations Office Architectural/Engineering Standard for snow loads);
- AWS D1.1, Structural Welding Code; and
- Steel Deck Institute, Design Manual for Composite Decks, Form Decks, Roof Decks, and Cellular Deck Floor Systems with Electrical Distribution.

The design of the secondary and nonstructural steels complies with the principal codes and standards identified previously, with the exception of ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992).

The conclusions in this section regarding the FPA design criteria are based on the evaluation findings in Section 4.1.3 of this SER. The design criteria and relevant codes and standards have been described sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

<u>Transfer Tunnel</u>

The Transfer Tunnel is structurally part of two separate areas. The south Transfer Tunnel section is integral with the storage area vaults and was designed as part of that structure. The north Transfer Tunnel section is integral with the transfer area structure and was designed as part of that structure.

<u>Canister Closure Area</u>

The CCA is structurally part of the transfer area structure and was designed as part of that structure.

Confinement Boundary Through-Wall Penetrations

Other than the site design criteria identified in Chapter 3 of the SAR, no specific design criteria for the confinement boundary through-wall penetrations have been provided.

Cask and Canister Trolleys and Cask Adapter

As identified in Sections 4.7.3.3.5, “Cask Trolley,” and 4.7.3.3.6, “Canister Trolley,” of the SAR, the design of the cask trolley considered the following conditions:

- Earthquake—The cask trolley and supporting rails are designed to resist the DBE. The acceptance criteria for the trolley is to remain locked in position during and following a seismic event while the trolley is parked. The trolley is also designed to remain on its rails during and following a seismic event at any intermediate position during travel between transfer locations.

- Fire or Explosion—The trolley meets the requirements of NFPA 70, National Electric Code, to minimize the likelihood and effect of fires that may occur from faulty electrical cabling and equipment. Credible fires or explosions in the CRA or Transfer Tunnel that may have an adverse effect on the trolley are discussed in Section 4.3.8 of the SAR.

- Flood—The lower section of the trolley may be subject to flooding. However, the trolley supports the bottom of the transfer cask and ISF canister approximately 2.4 m [8 ft] above the floor of the Transfer Tunnel. Because the maximum flood elevation is also approximately 2.4 m [8 ft] above the Transfer Tunnel floor, only the very bottom of the confinement boundaries would be submerged.

- Shielding Considerations—The stainless steel cask adapter installed on top of the transfer cask provides supplemental shielding during SNF removal from the cask. The shielding cask of the canister trolley is provided to minimize operator exposure during canister closure operations and canister trolley recovery and maintenance activities inside the Transfer Tunnel.

- Temperature Effects—The trolley is designed to operate within a temperature range of 0.0 EC [32 EF] to 40.6 EC [105 EF]. The trolley will not be used to transfer SNF if the temperature is outside this range.

For analysis, the cask and canister trolleys are considered equivalent to a service Class D (Heavy), Load Class L4 device as defined by CMAA No. 70. The cask trolley complies with the following principal specifications:

- NUREG–0612, Control of Heavy Loads at Nuclear Power Plants;
- NUREG–0554, Single-Failure-Proof Cranes for Nuclear Power Plants;
- CMAA No. 70, Specification for Electrical Overhead Traveling Cranes;
- AISC Manual of Steel Construction, 9th Edition;
- ANSI N14.6, American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 4,500 kg [10,000 lb] or More;

- ASME International B30.2 and Addenda B30.2a, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist); and
- AISC, Steel Construction Manual, 9^{th} edition (rails, rail support plates and cast-in-place anchor bolts only).

The cask and canister trolley design criteria and relevant codes and standards have been identified sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

<u>Cask and Canister Inflatable Seal, Check Valves, Relief Valves, and Connecting Tubing</u>

Other than the operational requirements and site design criteria identified in Chapter 3 of the SAR, no specific design criteria for the inflatable seals and associated valves and tubing have been provided.

<u>Fuel Handling Machine</u>

As identified in Section 4.7.3.3.7, “Fuel Handling Machine,” of the SAR, the design of the FHM considered the following conditions:

- Earthquake—The FHM and associated support structure and rails are designed to withstand seismic loads in unloaded and loaded conditions.

- Fire or Explosion—The FHM system is designed to meet the requirements of NFPA 70, National Electric Code, to minimize the likelihood and effect of any fires that may occur as a result of faulty electrical equipment.

- Temperature Effects—The crane will not be operated when FPA temperatures are below 0.0 EC [32 EF] or above 40.6 EC [156 EF].

- Decontamination Considerations—The paint on the FHM meets the requirements of ASTM D4082, Standard Test Method for Effects of Gamma Radiation on Coatings for Use in Light Water Nuclear Power Plants for Radiation Resistance.

- Protective Coatings—The FHM coatings are Service Level II in accordance with ASTM D5144-00, Standard Guide for Use of Protective Coating Standards in Nuclear Power Plants. At a minimum, the coating consists of two finish coats of epoxy paint covering a single coat of primer.

The FHM complies with the following principal specifications:

- NUREG–0612, Control of Heavy Loads at Nuclear Power Plants;
- NUREG–0554, Single-Failure-Proof Cranes for Nuclear Power Plants;
- CMAA No. 70, Specification for Electrical Overhead Traveling Cranes;
- ANSI N14.6, American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 4,500 kg [10,000 lb] or More;
- AISC, Manual of Steel Construction, 9^{th} Edition;
- ASME International B30.2 and Addenda B30.2a, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist);
- NFPA 70, National Electrical Code;

- AWS D1.1, Structural Welding Code—Steel; and
- ASME Code Section IX, Welding and Brazing Qualifications, 2001 Edition, including addenda and all supplements.

The conclusions in this section regarding the FHM design criteria are based on the evaluation findings in Section 4.1.3 of this SER. The design criteria and relevant codes and standards have been identified sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

Worktable and Tipping Machine

Other than the operational requirements and site design criteria identified in Chapter 3 of the SAR, no specific design criteria for the worktable and tipping machine have been provided.

HVAC and HVAC Breakaway Joint

The codes and standards listed below provide the principal design and construction requirements for the HVAC system:

- ASHRAE DG–1, Heating, Ventilating, and Air-Conditioning Design Guide for U.S. Department of Energy Nuclear Facilities;
- ASHRAE Handbook: Fundamentals;
- ASME International N509, Nuclear Power Plant Air-Cleaning Units and Components;
- ASME International N510, Testing of Nuclear Air Treatment Systems;
- Energy Research and Development Administration (ERDA) 76-21, Nuclear Air Cleaning Handbook; and
- American Conference of Governmental Industrial Hygienists: Industrial Ventilation—A Manual of Recommended Practice; and
- SMACNA, HVAC Duct Construction Specifications.

The conclusions in this section regarding the HVAC ductwork and HVAC breakaway joint design criteria are based on the evaluation findings in Section 4.1.3 of this SER. The design criteria and relevant codes and standards have been identified sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

Breathing Air System (Portion of System That Penetrates FPA Confinement Boundary)

Other than the site design criteria identified in Chapter 3 of the SAR, no specific design criteria for the confinement boundary through-wall penetrations have been provided.

MSM Through-Wall Tubes and Encasts

Other than the site design criteria identified in Chapter 3 of the SAR, no specific design criteria for the confinement boundary through-wall penetrations have been provided.

Storage Vault Inlet Vents and Exhaust Louvers

Other than the site design criteria identified in SAR Chapter 3, no specific design criteria for the vents and exhaust louvers has been provided.

Charge Face Cover Plate

The charge face cover plate is designed to the site criteria identified in Chapter 3 of the SAR and AISC, Manual of Steel Construction, 9th Edition.

Storage Tube Support Stool

The storage tube support stool is structurally considered part of the ISF storage tube and was designed as part of that structure.

Canister Handling Machine

As identified in Section 4.7.3.3.8, “Canister Handling Machine,” of the SAR, the design of the CHM and the storage area interfaces incorporates engineered features and safety provisions that address the following conditions.

- Tornado—The CHM is designed to withstand the effects of tornado winds and differential pressure. The tornado wind and differential pressure are evaluated in combination with other loads. Although it is likely that the CHM would withstand the effects of tornado missiles, tornado missile loads have not been explicitly incorporated into the design of the CHM hoist and control systems. The combined probability of a tornado occurring of sufficient strength to generate tornado missiles at the ISF Facility site at the same time the CHM is handling an ISF canister is estimated to be $<10^{-7}$/year and is, therefore, not considered credible.

- Earthquake—The CHM is designed to withstand the effects of the DBE. The seismic design of the CHM provides the bounding structural design basis for the CHM. The CHM is seismically designed to prevent failure during the DBE and to prevent damage to an ISF canister should the earthquake occur during handling operations. The CHM is also designed to ensure that deflections that may occur during an earthquake will not result in impact to the charge face of the storage vault. The girders, trolley, and turret are designed to limit the horizontal seismic deflections of the turret nose unit so the turret nose unit cannot trap an ISF canister when it is being inserted into the storage tube or the load and unload port. The vertical seismic displacement of the nose of the CHM relative to the charge face is designed to limit deflections to prevent the CHM turret and cask assembly from imparting a load on the charge face during the seismic event. The seismic switch will deenergize the CHM during an earthquake. Deenergizing the CHM will ensure it remains in a known safe state during and after the DBE.

- Fire or Explosion—Noncombustible and heat-resistant materials are used wherever practical throughout the CHM design. The CHM meets the requirements of NFPA 70, National Electric Code, to minimize the likelihood and effect of fires that may occur as a result of faulty electrical equipment. Deenergizing the CHM in the event of a fire incident will result in the seismic clamps engaging and clamping the rails to prevent bridge and trolley movement. The canister hoist brakes will engage and hold the canister. Interlocks and safety features on the CHM do not require electrical power to maintain the CHM in a safe state. Credible fires or explosions in the storage area that

may have an adverse effect on the CHM or SNF transfer operations are discussed in Section 4.3.8 of the SAR.

- Shielding Considerations—The CHM is designed to ensure dose rates to the operator remain ALARA during canister handling operational phases. The main cask body contains the cavity for the ISF canister and provides radiation protection using carbon steel gamma shielding, clad with a layer of Jabroc to provide neutron shielding.

- Temperature Effects—The CHM is designed to operate in the normal and off-normal temperature range that occurs in the storage area building. Structural materials are selected for the ability to operate during normal, off-normal, and accident conditions. The CHM will not be operated if the temperature in the storage area building is less than 0.0 EC [32 EF]. The CHM shall not be operated at temperatures greater than 40 EC [104 EF].

The CHM is designed with appropriate structures, mechanisms, restraints, and interlocks to prevent dropping or trapping the ISF canister during handling operations. The ISF canister hoist is designed as a single failure proof hoist to CMAA No. 70 (Crane Manufacturers Association of America, 1994) and NUREG–0554 (U.S. Nuclear Regulatory Commission, 1979). The ISF canister grapple is designed as a high-integrity grapple to ANSI N14.6 (American National Standards Institute/American Nuclear Society, 1993) (using the higher factors of safety). The ISF canister grapple incorporates mechanical interlocks that prevent the grapple jaws from releasing its load, unless the weight of the load is supported. If the grapple jaw open actuator is inadvertently energized while carrying an ISF canister, the canister will not be released from the grapple.

The CHM is designed in accordance with the following principal codes and specifications:

- NUREG–0554, Single-Failure-Proof Cranes for Nuclear Power Plants;
- NUREG–0612, Control of Heavy Loads at Nuclear Power Plants;
- CMAA No. 70, Specifications for Electrical Overhead Traveling Cranes;
- AISC, Manual of Steel Construction Allowable Stress Design, 9th Edition;
- ANSI N14.6, Special Lifting Devices for Shipping Containers Weighing 4,500 kg [10,000 lb] or More;
- ANSI/Institute of Electrical and Electronics Engineers, Inc. (IEEE) C2, National Electrical Safety Code;
- NFPA 70, National Electrical Code;
- ANSI/AISC N690 (American National Standards Institute/American Institute of Steel Construction, 1994), Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities;
- ASME NOG-1-1998
- ASME International B30.2, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist); and
- AWS D1.1, Structural Welding Code—Steel.

The conclusions in this section regarding the CHM design criteria are based on the evaluation findings in Section 4.1.3 of this SER. The design criteria and relevant codes and standards have been identified sufficiently in accordance with 10 CFR §72.24(c) and §72.120(a).

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 given in the SAR with respect to the applicable regulatory requirements.

Seismic Switch

The materials and corresponding codes and standards used in the design and construction of the seismic switch are controlled by meeting the requirements for procuring and accepting commercial grade items identified in the ISF Facility Quality Program Plan. Therefore, the requirements of 10 CFR §72.24(c)(3) and (4) are satisfied.

Electrical Interlocks

The materials and corresponding codes and standards used in the design and construction of the electrical interlocks are controlled by meeting the requirements for procuring and accepting commercial grade items identified in the ISF Facility Quality Program Plan. Therefore, the requirements of 10 CFR §72.24(c)(3) and (4) are satisfied.

Cask Receipt Crane and Associated Lifting Fixtures

The principal load carrying members of the cask receipt crane and other components that perform important to safety functions are constructed of the materials in Table 4.7-1 of the SAR. CMAA No. 70 (Crane Manufacturers Association of America, 1994) is the primary document used for fabrication, construction, and testing criteria for the cask receipt crane with the following exceptions and supplemental requirements:

- Welding is in accordance with AWS D1.1 rather than AWS D14.1;
- Anchor bolts are in accordance with AISC Manual of Steel Construction, 9th Edition;
- Lifting devices are fabricated, tested and inspected per ANSI N14.6; and
- NUREG–0554 and NUREG–0612 have been invoked and take precedence over CMAA No. 70 where applicable

Explicit materials for the associated lifting devices are not identified in the SAR. As indicated, these lifting devices will be designed and fabricated in accordance with the applicable codes and standards. These standards identify the acceptable material characteristics. The cask receipt crane and associated lifting devices materials have been identified in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Cask Receipt Area

The structural steels in the CRA are constructed of the materials in conformance with the following codes and standards:

- ASTM A36, Standard Specification for Structural Steel;

- ASTM A53, Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded, and Seamless;
- ASTM A242, Standard Specification for High-Strength Low Alloy Structural Steel;
- ASTM A572, Standard Specification for High-Strength, Low Alloy Columbium-Vanadium Steels of Structural Quality;
- ASTM A588, Standard Specification for High-Strength Low Alloy Structural Steel with 345-MPa [50-ksi] Minimum Yield Point to 10 cm [4 in] Thick; and
- ASTM A325, Standard Specification for High Strength Bolts for Structural Steel Joints.

Fabrication and inspection of the steel of the CRA are in accordance with:

- AISC Code of Standard Practice for Steel Buildings and Bridges;
- AWS D1.1, Structural Welding Code—Steel; and
- Secondary steel and architectural features of the CRA comply with the Uniform Building Code.

Based on the review of information presented in the SAR, the staff concludes materials to be used to construct the CRA structural steels have been identified adequately in accordance with 10 CFR §72.24 (c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Fuel Packaging Area

The structural steels in the FPA are constructed of the materials in conformance with the following codes and standards:

- ASTM A36, Standard Specification for Structural Steel;
- ASTM A53, Standard Specification for Pipe, Steel, Black and Hot Dipped, Zinc Coated, Welded, and Seamless;
- ASTM A242, Standard Specification for High-Strength Low alloy Structural Steel;
- ASTM A572, Standard Specification for High-Strength, Low Alloy Columbium-Vanadium Steels of Structural Quality;
- ASTM A588, Standard Specification for High-Strength Low Alloy Structural Steel with 345-MPa [50-ksi] Minimum Yield Point to 10 cm [4 in] Thick;
- ASTM A325, Standard Specification for High Strength Bolts for Structural Steel Joints;
- ASTM A759, Specification for Carbon-Steel Crane Rails; and
- ASTM A516 Grade 70, Pressure Vessel Plates, Carbon-Steel for Moderate and Lower Temperatures Service.

Based on review of the information presented in the SAR, the staff concludes materials to be used to construct the ISF Facility FPA reinforced concrete structures have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Transfer Tunnel

The Transfer Tunnel is structurally part of two separate areas. The south Transfer Tunnel section is integral with the storage area vaults, and materials are the same as that structure.

The north Transfer Tunnel section is integral with the transfer area structure, and materials are the same as that structure.

Canister Closure Area

The CCA is structurally part of the FPA and materials are the same as that structure.

Confinement Boundary Through-Wall Penetrations

No specific materials are identified for the confinement boundary through-wall penetrations. The confinement boundary through-wall penetrations will be designed and fabricated in accordance with the appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Cask and Canister Trolleys and Cask Adapter

Principal load carrying members of the cask and canister trolleys and other components that perform important to safety functions are constructed of the materials listed in Tables 4.7-2 and 4.7-4 of the SAR. Construction of the cask and canister trolleys complies with the following principal specifications:

- NUREG–0612, Control of Heavy Loads at Nuclear Power Plants;
- NUREG–0554, Single-Failure-Proof Cranes for Nuclear Power Plants;
- CMAA No. 70, Specification for Electrical Overhead Traveling Cranes;
- ASME International B30.2 and Addenda B30.2a, Overhead and Gantry Cranes (Top Running Bridge, Single or Multiple Girder, Top Running Trolley Hoist);
- ANSI N14.6, American National Standard for Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 4,500 kg [10,000 lb] or More;
- NFPA 70, National Electrical Code;
- AWS D1.1–2000, Structural Welding Code—Steel; and
- AISC, Steel Construction Manual, 9th Edition (rails, rail support plates and cast-in-place anchor bolts only).

CMAA No. 70 (Crane Manufacturers Association of America, 1994) is the primary document used for fabrication, construction, and testing criteria for the cask and canister trolleys with the following exceptions and supplemental requirements:

- Welding is in accordance with AWS D1.1 rather than AWS D14.1;
- Anchor bolts are in accordance with AISC Manual of Steel Construction, 9th Edition; and
- lifting devices are fabricated, tested, and inspected per ANSI N14.6.

Based on review of the information presented in the SAR, the staff concludes that materials to be used to construct the cask and canister trolleys and cask adapter have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Cask and Canister Inflatable Seal, Check Valves, Relief Valves and Connecting Tubing

No specific materials are identified for the cask seals. The cask seals will be designed and fabricated in accordance with appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Fuel Handling Machine

Principal load carrying members of the FHM are constructed of the materials listed in Table 4.7-3 of the SAR. NUREG–0554 and NUREG–0612 (U.S. Nuclear Regulatory Commission, 1979,1980) have been invoked and take precedence over CMAA No. 70 (Crane Manufacturers Association of America, 1994) where applicable. CMAA No. 70 is the primary document used for fabrication, construction, and testing criteria for the FHM with the following exceptions and supplemental requirements:

- Welding acceptance criteria are in accordance with AWS D1.1 rather than AWS D14.1;
- Weld procedures and welders will be qualified to AWS D1.1 or ASME Code Section IX;
- Anchor bolts are in accordance with AISC Manual of Steel Construction, 9th Edition; and
- Lifting devices are fabricated, tested, and inspected per ANSI N14.6.

Based on review of the information presented in the SAR, the staff concludes that materials to be used to construct the FHM have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Worktable and Tipping Machine

No specific materials are identified for the worktable and tipping machine. The worktable and tipping machine will be designed and fabricated in accordance with the appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed the proper materials for construction will be selected, in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

HVAC and HVAC Breakaway Joint

No specific materials are identified for the HVAC ducts and breakaway joint. The HVAC ducts and breakaway joint will be designed and fabricated in accordance with appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Breathing Air System (Portion of System That Penetrates FPA Confinement Boundary)

No specific materials are identified for the breathing air system penetration in the confinement boundary. The breathing air system penetration in the confinement boundary will be designed and fabricated in accordance with appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

MSM Through-Wall Tubes and Encasts

No specific materials are identified for the MSM through-wall tubes and encasts. The MSM through-wall tubes and encasts will be designed and fabricated in accordance with appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Storage Vault Inlet Vents and Exhaust Louvers

No specific materials are identified for the storage vault inlet vents and exhaust louvers. The storage vault inlet vents and exhaust louvers will be designed and fabricated in accordance with appropriate codes and standards. These standards identify the acceptable material characteristics. The staff concludes, if the applicable codes and standards are followed, the proper materials for construction will be selected in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Charge Face Cover Plate

The composition of the charge face cover plate is:

- Charge face cover plate—ASTM A36;
- Charge face cover plate cap screws—ANSI B18.3, ASTM A574; and
- Charge face cover plate coating—two-part epoxy paint.

Based on review of the information presented in the SAR, the staff concludes that materials to be used to construct the charge face cover plate have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Storage Tube Support Stool

The support stool assembly is made from the following materials:

- Support stool plate sections—ASTM A572 Grade 42, Type 1;
- Support stool alignment guides—ASTM A6, ASTM A572 Grade 42, Type 1;
- Support stool anchor bolts—ASTM A193, Grade B7;

- Support stool external surface coating—aluminum spray; and
- Surfaces of support stool in contact with grout—paint with primer.

Based on review of the information presented in the SAR, the staff concludes materials to be used to construct the storage tube support stool have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 10 CFR §72.24(c)(4).

Canister Handling Machine

Table 4.7-5 of the SAR lists the material specifications of the main structural components of the CHM. The requirements of the materials selected for the CHM satisfy the requirements of CMAA No. 70 (Crane Manufacturers Association of America, 1994) and the additional requirements of NUREG–0554 (U.S. Nuclear Regulatory Commission, 1979). Components or subassemblies of the bridge, trolley, and canister hoist are designed as either "structural" or "mechanical" components in accordance with subsections CMAA-70-3 and CMAA-70-4, respectively. CMAA No. 70 is the primary document used for fabrication, construction, and testing criteria for the CHM with the following exceptions and supplemental requirements:

- Welding is in accordance with AWS D1.1 rather than AWS D14.1;
- Anchor bolts are in accordance with AISC Manual of Steel Construction, 9th Edition;
- Lifting devices are fabricated, tested, and inspected per ANSI N14.6; and
- NUREG–0554 and NUREG–0612 have been invoked and take precedence over CMAA No. 70 where applicable.

Based on review of the information presented in the SAR, the staff concludes that the materials to be used to construct the CHM have been identified adequately in accordance with 10 CFR §72.24(c)(3). The applicant has identified the appropriate codes and standards in accordance with 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 finds that the structural analysis procedures have been identified and are in conformance with standard engineering practice. Other structures, systems, and components important to safety will be designed and analyzed to resist the loads and loading combinations specified in the design criteria. Analyses of other structures, systems, and components important to safety included loading conditions of dead and live loads, thermal loads, earthquake, tornado, wind, or tornado missiles, and fire, as applicable. The staff reviewed the structural analysis for other structures, systems, and components important to safety with respect to the regulatory requirements of 10 CFR §72.24 and §72.122.

Seismic Switch

Although designated as an important to safety component, the seismic switch is only called upon to perform its safety function during a seismic event. The components of the seismic switch will be commercial "off-the-shelf" items, purchased in accordance with the design criteria. As described in Sections 3.3.6 and 7.7.6 of the ISF Facility Quality Program Plan (Foster

Wheeler Environmental Corporation, 2004a), procedures will be implemented for certifying commercial grade items for use in important to safety applications. These requirements provide assurance that the seismic switch can perform its function during normal, off-normal, and accident conditions. Therefore, the staff concludes that the seismic switch meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Electrical Interlocks

The components of the electrical interlocks will be commercial "off-the-shelf" items, purchased in accordance with the design criteria. As described in Sections 3.3.6 and 7.7.6 of the ISF Facility Quality Program Plan (Foster Wheeler Environmental Corporation, 2004a), procedures will be implemented for certifying commercial grade items for use in important to safety applications. These requirements provide assurance that the electrical interlocks can perform their function during normal, off-normal, and accident conditions. Therefore, the staff concludes that the electrical interlocks meet the ISF Facility design criteria described in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Cask Receipt Crane and Associated Lifting Fixtures

This section addresses the structural analysis of the cask receipt crane hoist, equalizer beam, equalizer support beam, and main girder. The static and dynamic analyses of the cask receipt crane were performed with STAADPRO (Research Engineers International, 2001), a general-purpose finite element program. The cask receipt crane is represented by a generalized three-dimensional, lumped mass system interconnected by weightless elastic members. The model reflects the overall size, length, connectivity, and stiffness of various structural members. The finite element model for the cask receipt crane is shown in Figure 4.7-74 of the SAR for the hook-up condition.

A linear elastic response spectrum method using a 5-percent critically damped response spectra was employed for the seismic analysis. Modal participation factors and response spectrum values corresponding to the modal frequencies were used to select the significant modes. Modes in the flexible range were combined by the square root sum of the squares method while the modes in the rigid range, which account for the missing masses, were combined by the algebraic sum method consistent with Section 3.7.2 of NUREG–0800 (U.S. Nuclear Regulatory Commission, 1996). The responses obtained from the three direction analyses were combined in accordance with Regulatory Guide 1.92 (U.S. Nuclear Regulatory Commission, 1976).

The cask receipt crane was analyzed for three conditions: lifting a future 136-tonne [150-ton]-transportation cask and 4,536-kg [10,000 lb]-lifting device on the hook, lifting the 31.8-tonne- [35-ton]-transfer cask and lifting device on the hook, and no load on the hook. Both hook-up and hook-down positions were analyzed. The rope and the lower block with lifted weight behave as a pendulum at approximately 0.26 Hz during a seismic event. The horizontal seismic response is negligibly small because of this pendulum effect. The vertical frequency of the fixed trolley with the proposed transportation cask and lifting device on hook is close to the frequency region of the 5-percent damped response spectrum peak acceleration. Member design was based on CMAA No. 70 (Crane Manufacturers Association of America, 1994). A summary of the results is presented in Table 4.7-25 of the SAR as stress ratios for shear and

interaction ratios for combined axial force and bending for the primary members in the load path of the governing load cases. The design is in compliance with CMAA No. 70 for all load combinations. Because the ISF Facility SAR only describes the use of the cask receipt crane for lifting the transfer cask, which is lighter by a factor of approximately five from the transportation cask analyzed, significant additional margins are available for all members.

Slack rope conditions were examined by comparing the static deflection with the dynamic upward displacement at the hook location. Because the seismic displacements are less than the static deflection, there is no slack rope condition for seismic events in either the hook-up or hook-down position.

Analyses were conducted to assess the ability of the cask receipt crane to perform its function during normal, off-normal, and accident conditions. The load case used for the design is based on the potential future use of a hypothetical transportation cask; therefore, the results for the actual loads to be lifted as described in this license application will have a higher margin of safety. The structural members are sized based on the worst-case load conditions. Therefore, the staff concludes that the system meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) has been demonstrated.

<u>Cask Receipt Area</u>

The CRA structural steel was analyzed by using a frame element model in the finite element program STAADPRO (Research Engineers International, 2001). The steel structure was designed and analyzed as a bolted, braced frame except for the central tower. The center tower supporting the cask receipt crane was modeled with the end moments restrained to represent moment-resisting connections. STAADPRO includes a structural section library for rolled steel sections contained in the AISC manual. This library provides an accurate callout of the steel section properties used in the model. Self-weight of the structure is automatically lumped to the nodes, and additional external dead loads are accounted for by manually lumping mass at the appropriate nodes. The CRA model contains rigid elements and nodal constraints to simulate eccentricities, member offsets at multimember connections, and nodal coupling. Mass and stiffness characteristics of the cask receipt crane support beams and girders were explicitly modeled in the CRA analysis to correctly account for coupling between the cask receipt crane and the remainder of the building. The lifted load of 141 tonne [155 ton] was included as a vertical accelerated mass in the analysis. Significant masses of other equipment were applied at appropriate locations and positioned. The storage area is adjacent to the CRA and is structurally isolated from it by a seismic gap.

The static analysis of the CRA included the effects of self-weight, dead loads, live loads, and wind loads. The effects of structure-soil-structure interaction were captured in the CRA analysis by using an input response spectra generated from the soil-structure interaction analysis (discussed in Section 3.2.3.1.8 of the SAR). Modal response characteristics were evaluated and the fundamental frequencies in three global directions were noted. Mode shapes and level of mass participation were evaluated to check the dynamic model. The seismic response of the CRA was analyzed by the response spectra method. Modal combinations were performed by the 10-percent method to account for closely spaced nodes. The analysis was run for 500 modes to dynamically capture sufficient mass in the three directions, and 100 percent of the structure’s mass was captured by accounting for the remainder of the missing mass.

Spatial combination of the modal responses in the three orthogonal directions was performed by the square root of the sum of the squares method.

Structural steel was designed in accordance with the AISC manual allowable stress method as modified by the requirements of NUREG–1536 (U.S. Nuclear Regulatory Commission, 1997). The load combinations were calculated in accordance with the criteria presented in Section 3.2.5.2 of the SAR. Capacity/demand ratios were computed for selected members to show compliance with the design criteria. Steel section stresses calculated from the analysis were less than the allowable stresses for the loads and combinations considered. Table 4.7-9 of the SAR presents representative members important to safety from the center tower structure and their capacity-to-demand ratios to the factored allowable stresses in the AISC manual (American Institute of Steel Construction, 1989).

Analysis was conducted to assess the ability of the cask receipt structural steel to perform its function during normal, off-normal, and accident conditions. The structural members are sized based on the worst-case load conditions. Therefore, the staff concludes that the CRA structural steel design meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) has been demonstrated.

Fuel Packaging Area

The FPA analysis is discussed in Section 5.1.1.4 of this SER. This analysis includes all structures in the FPA. The findings made in Section 5.1.1.4 of this SER are applicable to this section.

Transfer Tunnel

The Transfer Tunnel is structurally part of two separate areas. The Transfer Tunnel south section is integral to the storage area vaults and was analyzed as part of the storage area structure. The Transfer Tunnel north section is integral to the transfer area structure and was analyzed as part of that structure. A seismic isolation joint between these two structures allows for differential movement during the DBE.

Canister Closure Area

The CCA is part of the FPA and is discussed in Section 5.1.4.1 of this SER. This analysis includes all structures in the FPA. The findings made in Section 5.1.4.1 of this SER are applicable to this section.

Confinement Boundary Through-Wall Penetrations

No specific analysis was performed to assess the ability of the confinement boundary through-wall penetrations to perform their functions during normal, off-normal, and accident conditions. The components will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes the system meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Cask and Canister Trolleys

The trolleys are designed as a metal frame on top of trolley trucks mounted on four rail wheels. The SAR summarized the structural evaluations performed in numerous calculations. The structural analyses of the trolleys are provided in several calculation packages as part of the response to the U.S. Nuclear Regulatory Commission (Foster Wheeler Environmental Corporation, 2003b).

- ISF–FW–CALC–0168, Structural Calculations for the Cask Trolley; and
- ISF–FW–CALC–0170, Structural Calculations for the Canister Trolley

The trolleys were analyzed using a frame element model in the finite element program RISA3D (RISA Technologies, 2000). The cask trolley finite element model used in the analysis is shown in Figure 4.7-75 of the SAR. The canister trolley finite element model used in the analysis is shown in Figure 4.7-76 of the SAR. The geometry and added mass were modeled consistent with the design. Boundary conditions used in the model at the bases of the trolleys were consistent with physical conditions.

Trolley vertical and lateral loads are represented by node loads. The cask and canister weights are applied as concentrated loads at the support floor level. The vertical cask and canister seismic loads are equivalent-concentrated loads applied at either the top or bottom of the cask and canister depending on the direction of seismic motion. Lateral cask and canister seismic loads are modeled as concentrated loads applied at the top and the bottom of the cask and canister.

A linear elastic, equivalent static method is used for seismic analysis. Equivalent static seismic forces are calculated by multiplying the weight of the trolley and lifted loads by a factor of 1.5 and using the design response spectra acceleration maxima for 4-percent critical damping. Results obtained by this method are conservative, compared with the dynamic response spectra method where each acceleration peak is reached at a different frequency. The equivalent static method is based on the simplification that the trolley behaves as a rigid unit, and its peak acceleration is the maxima of the input spectra. With such simplification, 100 percent of the mass is subject to the peak spectral acceleration. The trolley model is analyzed for two cases for the cask trolley and for two cases for the canister trolley: when the locking pin is engaged, and when the trolley is free to move along the length of the rail (this case does not control the design of the trolley members).

Maximum values of structural response of the three-directional components of earthquake motion were added to the static load response. Structural response combinations are calculated for restraint reactions, member forces, and nodal displacements. The maxima of the absolute values for the internal forces are computed and used to calculate member stresses.

Member stresses and unity checks for shear, bending, axial tension, and axial compression were calculated. An envelope of member forces was generated by taking the maximum of the absolute values of the design parameters for the load combinations for a particular case. Members subject to combined axial compression and bending are proportioned to satisfy the interaction requirements in the form of unity checks given in CMAA No. 70 (Crane Manufacturers Association of America, 1994). To maintain uniformity of the summary of results, only the final unity check results (ratios) are provided for all stress conditions.

Table 4.7-26 of the SAR provides a summary of the analysis results of the cask trolley, including unity checks for representative trolley members in the load path for the governing load case. Table 4.7-27 of the SAR provides a summary of the analysis results of the canister trolley. The designs are found to be compliant with code requirements.

An analysis was conducted to assess the ability of the trolley structural steel members to perform their functions during normal, off-normal, and accident conditions. The structural members are sized based on the worst-case load conditions. Therefore, the staff concludes that the cask and canister trolleys meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) has been demonstrated.

Cask and Canister Inflatable Seal, Check Valves, Relief Valves, and Connecting Tubing

Some components of the cask and canister inflatable seals will be commercial items, purchased in accordance with the design criteria. As described in Sections 3.3.6 and 7.7.6 of the ISF Facility Quality Program Plan (Foster Wheeler Environmental Corporation, 2004a), procedures will be implemented for certifying commercial grade items for use in important to safety applications. The remainder of the components will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes that the cask and canister inflatable seals and associated components meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Fuel Handling Machine

The SAR contains a summary of the structural evaluations performed in numerous calculations. The structural analysis of the FHM is provided in several calculation packages as part of the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b): ISF-FW-CALC-0221, Fuel Handling Machine.

A finite element model was used for the static load conditions and the modal seismic analysis. The finite element program used for the analysis of the FHM was COSMOS/M (Structural Research & Analysis Corporation, 2000). Analyses were performed with the trolley at the midspan and end travel positions. The trolley located at the one-fourth span location is enveloped by the midspan and end trolley travel positions.

A detailed finite element model of the FHM included major components of the bridge and trolley structures. The bridge portion of the FHM, presented in Figure 4.7-77 of the SAR, was composed of approximately 3,700 elements. The steel tube sections for the main beams and end trucks were modeled using thick-shell elements. The model also included end plates on the beams, plates in the wheel assemblies, and the bridge rails. The connections between the beams, end trucks, and wheel assemblies included some beam elements. Motors, gearboxes, wheels, and axles were modeled with stiff beam elements and lumped masses to account for weights and geometry of these components. The trolley structure, presented in Figure 4.7-78 of the SAR, was modeled in the same way as the bridge. The 4.54-tonne [5-ton] hoist was modeled with stiff three-dimensional beam elements and masses to approximate the center of gravity of the hoist drums, shafts, hoist drives, and brakes. The hoist cable was modeled with a beam element having axial stiffness of the cable. The PMS mast and arm were included as three-dimensional beam elements.

As required, boundary conditions varied for the load conditions considered. The finite element model had restraints at the contact surface of the wheels and cam followers as necessary to represent the supports of the structure. Reaction forces at the boundary conditions were checked for each load condition and compared with the applied loads.

The finite element model was analyzed for each of the static load cases using the static analysis features of COSMOS/M (Structural Research & Analysis Corporation, 2000). The analysis results in displacements at each node and stresses in each element for the individual load conditions. Combined stresses for each load combination were analyzed and individual elements were checked against the allowable stresses for that condition. The earthquake analysis of the FHM was completed by first solving the finite element model for frequencies and mode shapes. Forty modes were extracted. For the case with the trolley at midspan and the hoist fully loaded, frequencies ranged from 2.38 to 60.15 Hz. The appropriate response spectrum curves were then applied, and the resulting stresses were compared with the allowable stresses for each element.

The principal stresses and maximum shear stress were used to compute the maximum stress in accordance with the CMAA No. 70 requirements. Each element was also checked for shear. Allowable stresses in this condition are per CMAA No. 70, paragraph 3.4.3, Stress Level 3 (Crane Manufacturers Association of America, 1994). Plate stress ratios for the FHM are below 1.0 and, thus, are acceptable. A summary of the calculated stresses is provided in Tables 4.7-28 and 4.7-29 of the SAR. The finite element model provides beam stresses and loading at the major connections. The stresses in brackets, connections, bolts, wheel axles, and such, were manually calculated from the connection loads. The main hoist components were manually analyzed. Connections in the load path are classified as important to safety. The manipulator arm, mast, and hoist were modeled only to input their weights and centers of gravity. The design is found to be compliant with code requirements.

An analysis was conducted to assess the ability of the fuel handling structural steel members to perform their functions during normal, off-normal, and accident conditions. The structural members are sized based on the worst-case load conditions. Therefore, the staff concludes that the FHM meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) has been demonstrated.

<u>Worktable and Tipping Machine</u>

The SAR contains a summary of the structural evaluations on the worktable and tipping machine performed in several calculations. The structural analyses of the worktable and tipping machine are provided in the following calculation packages as part of the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0354, Worktable System Hold-Down Features Design Earthquake Analysis; and
- ISF–FW–CALC–0581, Worktable and Tipping Machine Seismic Calculations.

Some components of the worktable and tipping machine will be commercial items, purchased in accordance with the design criteria. As described in Sections 3.3.6 and 7.7.6 of the ISF Facility Quality Program Plan (Foster Wheeler Environmental Corporation, 2004a), procedures will be implemented for certifying commercial grade items for use in important to safety applications.

The remainder of the components will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes that the worktable and tipping machine meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

HVAC and HVAC Breakaway Joint

The components of the HVAC ducts and breakaway joints will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes that these components meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Breathing Air System (Portion of System That Penetrates FPA Confinement Boundary)

The components of the breathing air system confinement boundary will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes that these components meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

MSM Through-Wall Tubes and Encasts

The components of the MSM through-wall penetrations will be designed and fabricated in accordance with the appropriate codes and standards. Therefore, the staff concludes that these components meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Storage Vault Inlet Vents and Exhaust Louvers

Components of the storage vault inlet vents and exhaust louvers will be commercial items, purchased in accordance with the design criteria and appropriate codes and standards. As described in Sections 3.3.6 and 7.7.6 of the ISF Facility Quality Program Plan (Foster Wheeler Environmental Corporation, 2004a), procedures will be implemented for certifying commercial grade items for use in important to safety applications   Therefore, the staff concludes that these components meet the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) can be demonstrated.

Charge Face Cover Plate

The charge face cover plate is classified important to safety because it protects the storage tube assembly from tornado generated missiles. The charge face cover plate has been designed to the AISC manual (American Institute of Steel Construction, 1989). The charge face cover plate has been evaluated for static loads, live loads, seismic loads, tornado wind, differential pressure, and tornado-generated missile impact loads. The SAR contains a summary of the structural evaluations performed in numerous calculations. The structural analysis of the charge face cover plate is provided in the following calculation packages as part of the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0137, Charge Face Cover Plate Calculations; and

- ISF–FW–CALC–0464, Charge Face Cover Plate Resistance to Tornado Missiles

The charge face cover plate has been designed to withstand an impact from these missiles without damage to the storage tube assembly. The charge face cover plate has been designed to withstand the upward suction resulting from a tornado wind speed of 322 km/hr [200 mph], assuming the building sheeting failed.

Analysis was conducted to assess the ability of the charge face cover plate to perform its function during normal, off-normal, and accident conditions. The charge face covers are sized based on the worst-case load conditions. Therefore, the staff concludes that the charge face cover plate meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d), and §72.122(b) and (c) has been demonstrated.

Storage Tube Support Stool

The storage tube support stool is part of the ISF storage tube discussed in Section 5.1.4.2 of this SER. The findings made in Section 5.1.4.2 of this SER are applicable to this section.

Canister Handling Machine

Structural analysis of the CHM was performed to demonstrate compliance with the load and stress limit requirements of CMAA No. 70 (Crane Manufacturers Association of America, 1994) and the additional requirements of NUREG–0554, NUREG–0612 (U.S. Nuclear Regulatory Commission, 1979,1980), ANSI N14.6 (American National Standards Institute/American Nuclear Society, 1993), and NOG–1 (ASME International, 1998b), as applicable to individual subassemblies and load cases. The SAR contains a summary of the structural evaluations performed in numerous calculations. The structural analysis of the CHM is provided in the following calculation packages as part of the response to the staff's request for additional information (Foster Wheeler Environmental Corporation, 2003b):

- ISF–FW–CALC–0012, CHM Canister Grapple Stress Analysis—45.7-cm [18-in]-Canister Design;
- ISF-FW-CALC-0013, CHM Canister Grapple Stress Analysis—61.0-cm [24-in]-Canister Design;
- ISF–FW–CALC–0024, CHM Hoist Drum and Drive Components—Structural Analysis;
- ISF–FW–CALC–0092, TRIGA Fuel Basket—Thermal Stress Analysis in the CHM;
- ISF–FW–CALC–0103, TRIGA Fuel—Steady-State Thermal Analysis of the Short 45.7-cm [18-in]-ISF Canister and Basket in the CHM;
- ISF–FW–CALC–0196, Calculation for CHM Bridge Structure—Operational and Seismic;
- ISF–FW–CALC–0614, Normal and Accident Loads on the CHM Maintenance Hatch.

An overall view of the CHM finite element model with the trolley at midspan is provided in Figure 4.7-79 of the SAR. The analysis was performed using three-dimensional finite element beam and shell models. The general purpose, finite element program ANSYS (ANSYS Inc., 2001) was used for the analysis. The quarter, mid, and end of span models used in the analysis are identical structurally except for the relative trolley position. The finite element model is a beam/shell element representation of the machine.

Normal operating loads and stresses were compared with the stress limits dictated by the code permissible fatigue stress limits or other low stress limits in components not subject to fatigue. The canister handling materials are identified in Table 4.7.5 of the SAR. Permissible stresses are based on use of these materials as identified in CMMA No. 70 (Crane Manufacturers Associated of America, 1994) and ASME NOG-1 1998 (ASME International, 1998b). The additional loads resulting from wheel flange friction from skewing of the bridge and trolley on their rails also were compared with material allowables. Permissible stresses for these load cases are typically 10 percent higher than those for normal operating conditions. Extraordinary loads and stresses result from normal combined with additional events such as collision with the trolley or bridge end of travel buffers, axle break, or tornado wind effects. Permissible stresses for these load cases are typically 75 percent of the material tensile yield strength. Permissible stresses for seismic loads resulting from the DBE are typically 90 percent of the material tensile yield strength.

Normal operating loads during regular use operations were enhanced in the vertical direction by the dynamic factors of CMAA No. 70, Section 3.3.2.1.1.4 (Crane Manufacturers Association of America, 1994). The additional horizontal inertia loads induced by the trolley and bridge drive accelerations were obtained by applying horizontal accelerations to the ANSYS model (ANSYS Inc., 2001). Calculated stresses were compared with permissible stresses from CMAA No. 70, Section 3.4.2, or CMAA No. 70, Section 4.11, as appropriate. The canister grapple was analyzed against the conservative stress limits of ANSI N14.6 (American National Standards Institute/American Nuclear Society, 1993). Skew loads were calculated in accordance with CMAA No. 70, Section 3.3.2.1.2.2, and added to the normal operating loads. Calculated stresses were then compared with the permissible values from CMAA No. 70, Section 3.4.2.

It is assumed the internals of the electrical cubicles will be designed and fabricated so components mounted inside these cubicles will be dynamically rigid (i.e., have resonant frequencies above the zero period acceleration frequency).

Hand calculations were used as appropriate to calculate the fatigue stresses for the number of stress cycles corresponding to CMAA No. 70, Service Class D and L4 Load Class.

The extraordinary loadings were evaluated and the stresses calculated for the greatest of these loadings and compared with the permissible values from CMAA No. 70, Section 3.4.3. The rules of Section 3.4.3 also were applied to mechanical components designed to CMAA No. 70, Section 70-4, for extraordinary loadings. The effects of a 2.54-cm [1-in] drop following an axle break were analyzed and applied as a dynamic multiplier to the normal vertical static loads. Tornado wind loads were evaluated from the maximum wind speeds, air density, and drag coefficients of shapes in the wind path. The differential pressure from tornado wind was not included for the turret because the machine is open ended and the main body of the machine is greater than 30.5-cm [12-in]-thickness of steel.

A dynamic seismic modal analysis to ASME NOG–1–1998, Section NOG–4150 (ASME International, 1998b), using the response spectrum method, was performed to establish the response of the CHM to the DBE. As input, the analysis used the response spectra for x, y, and z directions at the long travel rails level of the CHM bridge. The magnitude of the DBE is such that additional sliding and frictional damping will be present at the clearances between the bridge rails and the wheel flanges and between the trolley rails and the wheel flanges. Therefore, the damping values appropriate to a bolted structure from Regulatory Guide 1.61

(U.S. Nuclear Regulatory Commission, 1973) are considered applicable to the overall assembly, and a response spectrum of 7 percent of the critical damping has been used in the seismic analysis. This value is consistent with the damping value guidelines from NOG–4153–8. The Grouping Method of mode combination was used in the analysis in accordance with NOG–4153–10(b)(1).

For the DBE, the permissible stresses are to be within the requirements of ASME NOG–1–1998 (ASME International, 1998b) for extreme environmental loading. The model loading conditions and the method of mode combination in the analyses conform to the requirements of NOG–4153. Stresses have been assessed to the requirement of NOG–4321, 4322, and 4324. Forces and moments at the joints and other interfaces also were tabulated to allow subsequent assessment of detailed mechanisms and bolted joints using hand calculations. Nose deflections also were tabulated to confirm these were not large enough to trap a canister during its transit through the vault/machine interface. The analyses were conducted with the seismic restraints engaged, representing the CHM locked over a storage tube or load/unload port (i.e., bridge locked to its rails, trolley locked to its rails, turret rotationally locked to trolley, and turret rotationally locked to nose casing).

The analysis produced separate lists of static loadings using the 1g vertical static weights of the components for the three trolley positions. These static loadings were used as input for the normal operating load cases. Additional runs with 1g horizontal loadings were applied and scaled to produce the forces and moments induced by the bridge and trolley acceleration inertias and the buffer collision deceleration loads. The plus and minus dynamic seismic loads were calculated separately and added or subtracted to the static loads to give the worst-case loading. For example, the maximum bridge and trolley wheel loads were obtained by adding static load plus seismic load and the maximum uplift at the wheels were obtained by subtracting static load minus seismic load. Calculated stresses were compared with ASME NOG–1 (ASME International, 1998b) allowable stress limits and found to be less than the code permissible values. The response spectrum analysis indicated a slack rope condition for the canister hoist. In accordance with the requirements of NOG–4154, a nonlinear time history analysis of the rope system was performed. This yielded a peak rope load less than the bounding value of 4g (1g static + 3g seismic), which was used for the structural calculations.

Table 4.7-30 of the SAR provides a summary of the lowest factors of safety derived from the structural calculations for the main structural components. Seismic loading generates the highest loads and stresses in the main structural components of the CHM. The factor of safety is defined as the ratio of allowable stress extracted from the applicable code to the calculated stress. A value of 1.0 or above signifies the component meets the structural code requirement. The design is found to be compliant with code requirements.

Analysis was conducted to assess the ability of the CHM plate to perform its function during normal, off-normal, and accident conditions. The CHM plate was sized based on the worst-case load conditions. Therefore, the staff concludes the system meets the ISF Facility design criteria in the SAR, and compliance with 10 CFR §72.24(a) and (d) and §72.122(b) and (c) have been demonstrated.

5.1.5 Other Structures, Systems, and Components Not Important to Safety

This section describes the design, design criteria, and design analysis for other structures, systems, and components not important to safety. There are no specific requirements identified in 10 CFR Part 72 for other structures, systems, and components not important to safety. Section 5.4.5, "Other SSCs," of NUREG–1567 (U.S. Nuclear Regulatory Commission, 2000) identifies the regulatory requirements applicable to other structures, systems, and components subject to U.S. Nuclear Regulatory Commission approval.

5.1.5.1 Description of Other Structures, Systems, and Components Not Important to Safety

As identified in Section 4.3, "Auxiliary Systems," of the SAR, the following structures, systems, and components are considered:

- Potable Water Supply (Section 4.1.2.3.1)
- Sanitary Wastewater (Section 4.1.2.3.2)
- Fire Water Supply (Section 4.1.2.3.3)
- Electrical Supply (Section 4.1.2.3.4)
- Communication and Alarm Systems (Section 4.1.2.3.5)
- Storage Facilities (Section 4.1.2.4)
- Stacks (Section 4.1.2.5)
- Electrical Systems Power Distribution System (Section 4.3.2.1.1)
- Electrical Systems Instrumentation and Controls (Section 4.3.2.1.2)
- Compressed Air (Section 4.3.3.1)
- Breathing Air (Section 4.3.3.2)
- Steam Supply and Distribution System (Section 4.3.4)
- Water Supply System (Section 4.3.5)
- Sanitary Sewage Treatment System (Section 4.3.4.1)
- Chemical Sewage Treatment System (Section 4.3.4.2)
- Communications and Alarm Systems (Section 4.3.7)
- Fire Protections Systems (Section 4.3.8)
- Maintenance Systems (Section 4.3.9)
- Cold Chemical Systems (Section 4.3.10)
- Air Sampling Systems (Section 4.3.11)
- FPA Shield Doors (Section 4.7.3.2.4)
- Decanning Machine (Section 4.7.3.2.8)
- Canister Welding Machine (Section 4.7.3.2.11)
- Vacuum Drying and Helium Fill System (Sections 4.7.3.2.12)

General descriptions of the other structures, systems, and components necessary to satisfy the requirements of 10 CFR §72.24(a) and (b) are in the SAR. The majority of these systems will be based on commercially available systems designed, fabricated, constructed, tested, and maintained in accordance with approved engineering practices.

The electrical power distribution system, except for the seismic switch (including the seismic sensor, load interrupters, and connections to power feeds), is classified as not important to safety and is not credited for mitigating any design basis accidents. The electrical distribution

system is designed to deenergize during seismic events to ensure the fuel handling equipment is in a known safe state. The electrical power distribution system is shown in Figure 4.3-10 of the SAR. The step-down transformer, standby diesel generator, and switchgear are at the substation. Motor control centers are in the electrical room on the first floor below the operating gallery. The UPS equipment is in the battery room adjacent to the electrical room. In certain off-normal or design basis event conditions, the power distribution system is allowed to experience controlled interruption, and facility electrical equipment and systems enter a passive, safe state.

As indicated in Section 4.3.2.1.2, “Instrumentation and Controls,” of the SAR, key instrumentation and control systems include the radiation monitoring system, the HVAC control system, the integrated data collection system, and the facility interlocks.

As indicated in Section 4.3.3, “Air Supply Systems,” of the SAR, there are two types of air supply systems at the ISF Facility: compressed air and breathing air. The compressed air and breathing air systems are not used to operate any fuel handling equipment and are not credited for accident mitigation.

As identified in Section 4.3.5, “Water Supply System,” of the SAR, the potable water system provides drinking water and other domestic needs at the ISF Facility site. Potable water also is used as a source of makeup to the chilled water loop in the HVAC system.

As identified in Section 4.3.6, “Sewage Treatment System,” of the SAR, the sanitary wastewater system at the ISF Facility is designed in accordance with the Uniform Plumbing Code and is classified not important to safety. Drainage and sewage are collected from the operations area, administration center, guardhouse, and visitor center, then gravity fed to the INTEC sanitary sewer line. The decontamination shower and floor and equipment drains in contaminated or potentially contaminated areas do not drain into the sanitary wastewater system.

As identified in Section 4.3.7, “Communications and Alarm Systems,” of the SAR, the communication and alarm systems at the ISF Facility consist of three functional groups:

- Nonemergency communications (phone and voice paging) system
- Fire detection, alarm, and emergency communication system
- Data communication (broadband local area network) system

As identified in Section 4.3.8, “Fire Protection System,” of the SAR, the fire protection system is designed in accordance with ANSI/ANS 57.9 (American National Standards Institute/American Nuclear Society, 1992), NFPA 801 (National Fire Protection Association, 1998) and other applicable NFPA codes and standards, and NUREG–1567 and NUREG–0800 (U.S. Nuclear Regulatory Commission, 2000,1996). The fire protection system consists of monitoring, detection, alarm, suppression, and extinguishing systems to protect the area or equipment from damage by fire. The following lists various fire water system components and respective codes:

- Sprinkler systems designed in accordance with NFPA 13;
- Standpipe and hose stations designed in accordance with NFPA 14;
- INTEC fire pumps and water supply tanks provided in accordance with NFPA 20 and NFPA 22;

- Fire hydrants and water mains designed and installed in accordance with NFPA 24 and American Water Works Association specifications;
- Portable fire extinguishers provided in accordance with NFPA 10;
- Fire protection equipment including the sprinkler systems, standpipe, and hose connections in the ISF building, yard hydrants, ISF Facility underground fire main loop, and all associated components maintained in accordance with NFPA 25;
- Fire detection systems designed in accordance with NFPA 72;
- Lightning protection designed and installed in accordance with NFPA 780; and
- ISF building occupancy classification in accordance with the Uniform Building Code.

The decanning machine, shown in Figure 4.7-23 of the SAR, is used to remove a small upper section of the can or salvage can that contains the Peach Bottom Core–1 fuel elements to allow removal and storage in the ISF baskets. The decanning machine is secured to a bench vessel using alignment dowels installed in the workbench. These studs align the tool during installation and secure the tool against seismic forces. The decanning machine's lower base plate and spool assembly also interface with the lower section of the bench vessel to provide seismic restraint for the full length of the SNF element. The decanning machine is classified as not important to safety.

Section 4.7.3.2.11, "Canister Welding System," of the SAR describes the system located inside the CCA. The canister welding system is used to perform the circumferential weld between the ISF canister lid assembly and the body assembly after the SNF has been loaded and then performs the seal weld on the vent plug after completing the vacuum drying and helium backfilling processes. The welding system consists of two remote controlled, automated welding machines and a common control/supply unit. The welding system is capable of completing the weld of the lid assembly to the body assembly in accordance with the requirements of the ASME Section III, Division 1, Subsection NB and Code Case N-595-2 (ASME International, 1998a). The welding process is a multipass, full penetration, single-sided Category B butt weld, based on ASME NB3351.2. The vent plug seal weld is a single-pass seal weld. The closure welds are inspected and tested in accordance with the requirements of the ASME Subsection NB–5000 (ASME International, 2001).

Section 4.7.3.2.12, "Vacuum Drying and Helium Fill System," of the SAR provides a description of this system (Figure 4.7-16 of the SAR). The system is used to vacuum dry the canister and SNF to acceptable levels of dryness and to provide a suitably inert canister environment, thus preventing degradation of the SNF and ISF canister internals by introducing helium cover gas. The system is designed to leak test, to the required acceptance standards, the canister lid assembly to the body assembly circumferential weld and the vent plug seal weld.

Appendix A of the SAR identifies trailers No. 71801 and No. 71808 as those used to move the SNF within the CRA. The trailers are commercial grade systems that have no specific code or specification criteria. Trailer No. 71808 is a flatbed trailer with fixed trunnion supports and, at the present time, only can be used to transport the Peach Bottom–1 cask. Trailer No. 71801 is a lowboy trailer with an adjustable front trunnion support that can accommodate the Peach Bottom–1 and Peach Bottom–2 transfer casks. The applicant (Foster Wheeler Environmental Corporation, 2003b) has indicated that U.S. Department of Energy–Idaho Operations Office will modify trailer No. 71808 so that it can be used with both casks.

5.1.5.2 Design Criteria for Other Structures, Systems, and Components Not Important to Safety

The design criteria for the various other structures, systems, and components not important to safety are identified in Chapter 3 of the SAR. These design criteria are based on commonly used codes and standards. The design of the other structures, systems, and components not important to safety permits inspection, maintenance, and testing. The inspection, maintenance, and testing requirements are based on the appropriate codes and standards. This design allows emergency capability. The layout of the ISF Facility allows areas to be reached in the event of an accident.

5.1.5.3 Material Properties for Other Structures, Systems, and Components Not Important to Safety

No specific material properties are identified in the SAR for the other structures, systems, and components not important to safety. However, material properties must satisfy the code or standards used for the structures, systems, and components as required and, therefore, satisfy the requirement of 10 CFR §72.24(c)(3).

5.1.5.4 Structural Analysis for Other Structures, Systems, and Components Not Important to Safety

Other structures, systems, and components not important to safety will be designed based on standard engineering practice in accordance with the applicable codes and standards. In most cases, these structures, systems, and components are commercially available, and their design to standard industrial requirements is acceptable. This demonstrates compliance with the requirement of 10 CFR §72.24(d) and (i) and the applicable section of 10 CFR §72.122.

5.2 Evaluation Findings

Based on review of the SAR, the staff makes the following determinations:

- The SAR, including the materials incorporated by reference, adequately describes the materials used for the structures, systems, and components important to safety and the suitability of those materials for the intended functions in sufficient detail to evaluate their effectiveness in compliance with 10 CFR 72.24(c)(3).

- There will not be a pool or pool confinement at the proposed ISF Facility.

- The SAR adequately describes all structures, systems, and components important to safety, providing drawings and text in sufficient detail to allow evaluation of the structural effectiveness to meet the requirements of 10 CFR §72.24(b), (c), (d)(1), and (d)(2); and §72.122(c). The structural analysis procedures used by the applicant have been identified. The relationship between the design basis and the design criteria has been identified in accordance with 10 CFR §72.24(a). The materials of construction have been identified. The applicable codes and standards used in the analysis of the reinforced concrete structures have been established.

- Appendix A of the SAR adequately describes the structures, systems, and components important to safety related to the transfer casks. This appendix provides drawings and text in sufficient detail to allow evaluation of the structural effectiveness to meet the requirements of 10 CFR §72.24(b), (c), (d)(1), and (d)(2), and 10 CFR §72.122(c). Structural analysis procedures and the relationship between the design basis and the design criteria have been identified. The transfer cask is a heavy-walled cylindrical vessel constructed of carbon steel and lead filled for radiation shielding, as required by 10 CFR §72.126(a).

- The structures, systems, and components important to safety are designed, fabricated, erected, and tested to quality standards commensurate with the importance to safety functions to be performed. The structures, systems, and components important to safety are classified based on their primary functions and importance to overall safety. Therefore, the requirements of 10 CFR §72.122(a) are satisfied.

- The applicant has met the requirements of 10 CFR §72.122(a). The material properties of structures, systems, and components important to safety conform to quality standards commensurate with their safety functions.

- The applicant has met the requirements of 10 CFR §72.122(h)(1). The design of the dry cask storage system and the selection of materials adequately protects the SNF cladding against degradation that might otherwise lead to gross rupture of the cladding.

- The structures, systems, and components important to safety are designed to accommodate the combined loads of normal, off-normal, accident, and natural phenomena events with an adequate margin of safety. The structural analysis demonstrates that the structures, systems, and components important to safety are designed to resist the loads based on the site characteristics and environmental conditions for normal operations and during postulated off-normal and accident events in accordance with 10 CFR §72.24(d)(1) and (d)(2). The structural analysis demonstrates that the structures, systems, and components important to safety are designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, lightning, and floods without impairing the capability to perform safety functions. Stresses at critical locations of structures, systems, and components for bounding design loads are determined by analysis. During the design process, the section properties were adjusted to ensure that the capacity of all structural elements at all locations exceeds the demand. Total stresses for the combined loads of normal, off-normal, accident, and natural phenomena events are acceptable and are found to be within the limits of applicable codes, standards, and specifications. Therefore, the requirements of 10 CFR §72.122(b)(1) and (2) are satisfied.

- The descriptions of structures, systems, and components important to safety include consideration of inspection, maintenance, and testing. Components requiring inspection and maintenance are identified, and operational procedures are summarized. Therefore, the requirements of 10 CFR §72.122(f) are satisfied.

- The U.S. Department of Energy–Idaho Operations Office, outside of ISF operations, is responsible for all required inspection and maintenance of the transfer casks. Therefore, no findings are made with respect to 10 CFR §72.122(f) for the transfer cask.

- The ISF Facility design also allows emergency capabilities so that access to critical locations and regions in the event of emergencies is possible. In addition, the lifting components are designed to hold the load in event of emergencies. Therefore, the requirements of 10 CFR §72.122(g) are satisfied.

- The applicant has demonstrated that the material properties of structures, systems, and components important to safety will be maintained during normal, off-normal, and accident conditions, so that the SNF can be retrieved readily for further processing or disposal without posing operational safety problems as required by 10 CFR §72.122(l).

- The applicant has met the requirements of 10 CFR §72.122(h)(1). The design of the dry cask storage system and the selection of materials adequately protect the SNF cladding against degradation that might otherwise lead to gross rupture of the cladding.

- The SNF handling and storage systems are designed to ensure adequate safety during normal and accident conditions. The applicant has committed to restrict transfer cask lifting operations to temperatures not less than −7 °C [20 °F]. Therefore, the applicant has met the requirements of 10 CFR §72.128(a).

- The transfer cask trunnion design meets the requisite single-failure-proof criteria prescribed in NUREG–0612. The transfer casks are designed to ensure confinement during a drop event onto a transport trailer caused by failure of the trunnion welds. Therefore, the applicant has met the structural requirements for the transfer casks in accordance with 10 CFR §72.120(a) and §72.128(a).

5.3 References

American Concrete Institute. *Building Code Requirements for Structural Concrete.* ACI 318-99. Detroit, MI: American Concrete Institute. 1999.

American Concrete Institute. *Code Requirements for Nuclear Safety Related Concrete Structures.* ACI 349-97. Detroit, MI: American Concrete Institute. 1998.

American Institute of Steel Construction. *Manual of Steel Construction, Allowable Stress Design*, 9th Edition. Chicago IL: American Institute of Steel Construction. 1989.

American National Standards Institute/American Institute of Steel Construction. *Specification for the Design, Fabrication and Erection of Steel Safety Related Structures for Nuclear Facilities*. ANSI/AISC N690. 1994.

American National Standards Institute/American Nuclear Society. *Design Criteria for an Independent Spent Fuel Storage Installation.* Dry Storage Type. ANSI/ANS 57.9. La Grange Park, IL: American National Standards Institute/American Nuclear Society. 1992.

American National Standards Institute/American Nuclear Society. *Radioactive Materials—Special Lifting Devices for Shipping Containers Weighing 10,000 Pounds (4500 kg) or More*. ANSI N14.6. La Grange Park, IL: American National Standards Institute/American Nuclear Society. 1993.

American National Standards Institute/American Nuclear Society. *Nuclear Power Plant Air Cleaning Units and Components*. ANSI/ANS N509. La Grange Park, IL: American National Standards Institute/American Nuclear Society. 1989a.

American National Standards Institute/American Nuclear Society. *Testing of Nuclear Air Treatment Systems*. ANSI/ANS N510. La Grange Park, IL: American National Standards Institute/American Nuclear Society. 1989b.

American Society of Civil Engineers. *Minimum Design Loads for Building and Other Structures*. ASCE 7-98. Reston, VA: American Society of Civil Engineering. 1999.

American Society of Civil Engineers. *Seismic Analysis of Safety-Related Nuclear Structures and Commentary on Standard for Seismic Analysis of Safety-Related Nuclear Structures*. ASCE 4-98. Reston, VA: American Society of Civil Engineering. 1998.

American Society for Testing and Materials. *Annual Book of ASTM Standards. Section 1, Volume 01.04.* Philadelphia, PA: American Society for Testing and Materials. 2000.

American Welding Society. *Structural Welding Code Steel*. AWS D1.1. Miami, FL: American Welding Society. 2002.

ANSYS Inc. *ANSYS Simulation and Analysis Software*. Version 5.7. Canansburg, PA: ANSYS Inc. 2001.

ASME International. *ASME Boiler and Pressure Vessel Code, Section VIII.* New York City, NY: ASME International. 1962b.

ASME International. *ASME Boiler and Pressure Vessel Code. Section IX.* New York City, NY: ASME International. 1962c.

ASME International. *ASME Boiler and Pressure Vessel Code. Section III, Division 1*. New York City, NY: ASME International. 1998a.

ASME International. *Rules for Construction of Overhead and Gantry Cranes (Top Running Bridge, Multiple Girder)*. ASME NOG–1. New York City, NY: ASME International. 1998b.

ASME International. *ASME Boiler and Pressure Vessel Code.* Section II. New York City, NY: ASME International. 1998c.

ASME International. *ASME International Boiler and Pressure Vessel Code.* Section III, Division 1 Subsection NB–5000. New York City, NY: ASME International. 2001.

Battelle Memorial Institute. *Safety Analysis for the Shipment of Peach Bottom No.1 Irradiated Fuel Elements in Whitehead and Kales Shipping Cask Model No PB–1*. Columbus, OH: Battelle Memorial Institute. 1970.

Computers and Structures Inc. *SAP2000 Integrated Software for Structural Analysis and Design.* Berkeley CA: Computers and Structures Inc. 2000.

Crane Manufacturers Association of America. *Specifications for Top Running Bridge and Gantry Type Multiple Girder Electric Overhead Traveling Cranes*. Specification No. 70. Charlotte, NC: Crane Manufacturers Association of America. 1994.

Foster Wheeler Environmental Corporation. *Idaho Spent Fuel Facility Response to NRC Follow-up Thermal Analyses Questions*. FW–NRC–ISF–04–0087. Docket 72-25. Morris Plains, NJ: Foster Wheeler Environmental Corporation. April 2004.

Foster Wheeler Environmental Corporation. *Idaho Spent Fuel Facility Safety Analysis Report*. ISF–FW–RPT–0033. Docket 72-25. Amendment 3. Morris Plains, NJ: Foster Wheeler Environmental Corporation. November 2003a.

Foster Wheeler Environmental Corporation. *Response to Request for Additional Information*. Idaho Spent Fuel Facility License Application. FW–NRC–ISF–03–0010. Richland, WA: Foster Wheeler Environmental Corporation, Idaho Spent Fuel Facility Project. January 22, 2003b.

Foster Wheeler Environmental Corporation. *Response to NRC Second Round Request for Additional Information*. Idaho Spent Fuel Facility License Application. FW–NRC–ISF–03–0198. Richland, WA: Foster Wheeler Environmental Corporation, Idaho Spent Fuel Facility Project. August 28, 2003c.

Foster Wheeler Environmental Corporation. *Response to NRC Follow-up Transfer Cask Questions*. Idaho Spent Fuel Facility License Application. FW–NRC–ISF–04–0111. Richland, WA: Foster Wheeler Environmental Corporation, Idaho Spent Fuel Facility Project. May 21, 2004.

Foster Wheeler Environmental Corporation. *Revision to Quality Program Plan*. Idaho Spent Fuel Facility. ISF-FW-PLN-0017. Richland, WA: Foster Wheeler Environmental Corporation, Idaho Spent Fuel Facility Project. May 28, 2004a.

Livermore Software Technology Corp. *LS-DYNA Software*. Livermore, CA: Livermore Software Technology Corp. 2001.

National Fire Protection Association. *Standard for Installation of Lightning Protection Systems.* NFPA 780. Quincy, MA: National Fire Protection Association. 1997.

National Fire Protection Association. *Standard for Fire Protection for Facilities Handling Radioactive Materials*. NFPA 801. Quincy, MA: National Fire Protection Association. 1998.

National Fire Protection Association. *National Electrical Code. NFPA 70*. Quincy, MA: National Fire Protection Association. 1999.

Research Engineers International. *STAAD/PRO Structural Engineering Design and Analysis Software*. Yorba Linda, CA: Research Engineers International. 2001.

Rinebolt, J.A. and W.J. Harris. *Effect of Alloying Elements on Notch Toughness of Pearlitic Steels*. *Transactions of the American Society for Metals*. Vol. 43. pp. 1,175–1,214. 1951.

RISA Technologies. *Easy 3D Structural Engineering Software for Analysis & Design of General Frame, Truss, or Plate/Shell Structures, RISA–3D*. Version 4.1. Foothill Ranch, CA: RISA Technologies. 2000.

Roe, G.J. *Notch Toughness of Steels in Metals Handbook.* Vol. 1—Properties and Selection: Irons and Steels. pp. 689–709. Metals Park, OH: American Society for Metals. 1978.

Structural Research & Analysis Corporation. *COSMOS/M*. Version 2.6. Los Angeles, CA: Structural Research & Analysis Corporation. 2000.

U.S. Department of Energy–Idaho Operations Office. *Drop Evaluation of the Peach Bottom Cask Without External Impact Limiters.* Engineering Design File 3151. Rev. 2. Idaho Falls, ID: U.S. Department of Energy–Idaho Operations Office. March 3, 2003.

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

U.S. Nuclear Regulatory Commission. NUREG–1536, *Standard Review Plan for Dry Storage Systems.* Washington, DC: U.S. Nuclear Regulatory Commission. 1997.

U.S. Nuclear Regulatory Commission. NUREG–0800, *Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants*. Washington, DC: U.S. Nuclear Regulatory Commission. 1996.

U.S. Nuclear Regulatory Commission. NUREG–0612, *Control of Heavy Loads at Nuclear Power Plants*. Washington, DC: U.S. Nuclear Regulatory Commission. 1980.

U.S. Nuclear Regulatory Commission. NUREG–0554, *Single-Failure-Proof Cranes for Nuclear Power Plants*. Washington, DC: U.S. Nuclear Regulatory Commission. 1979.

U.S. Nuclear Regulatory Commission. Regulatory Guide 1.92, *Combining Modal Responses and Spatial Components in Seismic Response Analysis*. Rev. 1. Washington, DC: U.S. Nuclear Regulatory Commission. 1976.

U.S. Nuclear Regulatory Commission. Regulatory Guide 1.76, *Design Basis Tornado for Nuclear Power Plants*. Washington, DC: U.S. Nuclear Regulatory Commission. 1974.

U.S. Nuclear Regulatory Commission. Regulatory Guide 1.61, *Damping Values for Seismic Design of Nuclear Power Plants.* Washington, DC: U.S. Nuclear Regulatory Commission. 1973.

Westinghouse Electric Corporation. *Safety Analysis for Shipment of LWBR Fuel in the Peach Bottom PB-2 Cask for ECF to ICPP*. WAPD–LP(EC)FD–50. West Mifflin, PA: Bettis Atomic Laboratory, Westinghouse Electric Corporation. 1986.